Michigan Journal of International Law

Volume 10 | Issue 2

1989

Stratospheric Ozone Depletion: A Challenge for International Environmental Law and Policy

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STRATOSPHERIC OZONE DEPLETION: A CHALLENGE FOR INTERNATIONAL ENVIRONMENTAL LAW AND POLICY

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I. INTRODUCTION

Researchers discovered in the fall of 1987 that the loss of ozone in the Antarctic had climbed to 50 percent during the austral spring,[1] a phenomenon not predicted by theorists' models and studies of the chemical behavior of stratospheric gases.[2] This was accompanied by a finding that chlorine monoxide levels at certain altitudes revealed 500 times normal concentrations.[3]

On the heels of this disquieting discovery, the authoritative International Ozone Trends Panel,[4] a creation of the National Aeronautics and Space Administration (NASA), in collaboration with other federal agencies and international organizations, including the United Nations Environment Programme (UNEP), reported a global loss of ozone during the past seventeen years.[5] A few months later, in May 1988, a group of scientists at the Polar Ozone Workshop in Snowmass, Colorado, reported the first evidence of ozone destruction in the Arc-

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I am grateful to several of my colleagues at the University of Denver College of Law Library, especially Patricia Murphy and Mary Wilder, and to Dolores Eddy, Librarian, EPA Region Eight Library in Denver, for locating and acquiring for me several congressional reports and documents and other recently released government documents which were not yet generally available. I am also indebted to Steve Berlant, J.D., 1988, University of Denver College of Law, for his research assistance.

1. R. W. WATSON *et al*, PRESENT STATE OF KNOWLEDGE OF THE UPPER ATMOSPHERE 1988: AN ASSESSMENT REPORT 18 (NASA Ref. Pub. 1208, Aug. 1988) [hereinafter OZONE TRENDS PANEL REPORT]. *See also* Shabecoff, *Antarctic Ozone Loss Is Worsening*, N.Y. Times, October 1, 1987, at 16, col. 4.

2. *See* Kerr, *Ozone Hole Bodes Ill for the Globe*, 241 SCIENCE 785 (1988).

3. Shell, *Solo Flights into the Ozone Hole Reveal Its Causes*, SMITHSONIAN, Feb. 1988, at 142, 154 (reported by James Anderson, Philip S. Weld Professor in Atmospheric Chemistry at Harvard University).

4. In the fall of 1986 NASA decided to coordinate and sponsor with the Federal Aviation Administration (FAA), the National Oceanic Atmospheric Administration (NOAA), the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), a review of all ground-based and satellite-based data. Ifiedt selected the Ozone Trends Panel, comprising eminent scientists from federal agencies, research institutions, private industry, and universities. OZONE TRENDS PANEL REPORT, *supra* note 1, at 2.

5. *Id.* at 4.

tic.[6] A consensus has seemingly emerged in the scientific community that humanly-induced chemical change in the stratosphere is responsible in whole, or in part, for the rapid depletion of Antarctic ozone.[7]

Another phenomenon of growing concern is global warming. In November 1988, a joint intergovernmental panel of the United Nations Environment Programme ("UNEP") and the World Meteorological Organization ("WMO") considered global warming as "the most important environmental concern of our day."[8] One of the panel's tasks is to study the impact of the increased concentration in the atmosphere of greenhouse gases, which include carbon dioxide (CO_2), methane, nitrogen oxides, and chlorofluorocarbons ("CFCs"), on global climate.[9]

Implications of these trends — stratospheric ozone loss and global warming — are far-reaching.[10] They have prompted scientists to further test and refine their models and theories,[11] and have challenged decision makers to explore policy options with an unprecedented urgency.[12] A study of the legal framework within which decision makers can effectuate their preferred policies constitutes the focus of this article. Thus, the first part of the article addresses the phenomenon of stratospheric ozone depletion, noting significant recent developments, and discussing their ramifications. This is followed by an inquiry into pertinent international and U.S. responses to ozone depletion. Recent developments in international environmental law provide an appropriate context for this inquiry. The adequacy of these responses is as-

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6. *See* Kerr, *Evidence of Arctic Ozone Destruction*, 240 SCIENCE 1144 (1988). *See also Scientist Fears Hole in Ozone Is Developing Over the Arctic*, N.Y. Times, May 18, 1988, at 10, col. 5; Browne, *New Ozone Threat: Scientists Fear Layer Is Eroding at North Pole*, N.Y. Times, Oct. 11, 1988, at B7, col. 1.

7. *See* OZONE TRENDS PANEL REPORT, *supra* note 1, at 3.

8. For a brief report on the 30-country panel's November 9-11 meeting in Geneva, see 11 Int'l Env't Rep. (BNA), at 644 (Dec. 14, 1988).

9. *Id.*

10. *See generally* U.S. ENVIRONMENTAL PROTECTION AGENCY, 1-8 ASSESSING THE RISKS OF TRACE GASSES THAT CAN MODIFY THE STRATOSPHERE (Office of Air and Radiation, Dec. 1987) [hereinafter ASSESSING THE RISKS OF TRACE GASSES].

11. *See generally* Kerr, *Is the Greenhouse Here?*, 239 SCIENCE 559, 561 (1988).

12. In the 100th Congress, two bills were introduced in the U.S. Senate: Senate Bill 2663/2666, entitled the "Global Environment Protection Act of 1988," introduced on July 27, 1988, by Senators Stafford, Baucus, Chafee, Durenberger, and Gore (S. Res. 2663,2666, 100th Cong., 2d Sess., 134 CONG. REC. S10112, 10282 (1988)) [hereinafter Stafford Bill]; and Senate Bill 2667, to establish a national energy policy to reduce global warming, and for other purposes, introduced on July 28, 1988, by Senators Wirth, Johnston, Bumpers, Fowler, Matsunaga, Pell, Melcher, Sanford, Gore, Stafford, Baucus, Chafee, Danforth, Bingham, Inouye, Heinz, Evans, and Harkin, (S. Res. 2667, *id.* at S10282 (1988)) [hereinafter Wirth Bill]. In the 101st Congress, several more bills were introduced. *See infra* notes 285, 290-291.

sessed in the next section. Recommendations follow in the concluding section.

II. STRATOSPHERIC OZONE DEPLETION

A. *The Problem*

Ozone is a pollutant at ground level and low altitudes.[13] However, in the upper part of the atmosphere, known as the stratosphere, it acts as a barrier against the ultraviolet rays of the sun, effectively absorbing them and thus protecting the earth from their harmful effects on human health, agricultural productivity, and fisheries.[14] That is why its loss in the stratosphere is critical.

Ozone occurs in the stratosphere as ultraviolet solar radiation causes photochemical reactions, continuously converting oxygen (O_2) to ozone (O_3) and back to oxygen.[15] Human activities are disturbing this production-and-loss balance and are causing ozone layer modification by chemical catalytic processes of nitrogen, chlorine, and hydrogen oxides.[16] To illustrate, chlorine is a catalytic agent which destroys ozone by promoting the following reactions:[17] a chlorine (Cl) atom reacting with ozone (O_3) forms ClO and O_2. ClO then reacts with another O_3, forming two molecules of O_2 and releasing the chlorine atom. Thus, after converting two molecules of ozone to three molecules of oxygen the chlorine is ready to restart the process. Consequently, a single chlorine atom is capable of destroying thousands of ozone molecules before returning to the lower atmosphere, called troposphere, and being rained out as hydrochloric acid.

Scientists have found a rapid increase in atmospheric concentra-

13. *See, e.g.*, Russell, *Ozone Pollution: The Hard Choices*, 241 SCIENCE 1275-76 (1988); Manserus, *How the Lung Reacts to Ozone Pollution*, N.Y. Times, Aug. 23, 1984, § 4, at 7, col. 1.

14. *See* R.T. WATSON, M.A. GELLER, R.S. STOLARSKI & R.F. HAMPSON, PRESENT STATE OF KNOWLEDGE OF THE UPPER ATMOSPHERE: AN ASSESSMENT REPORT 19 (NASA Ref. Pub. 1162, May 1986) [hereinafter 1986 ASSESSMENT REPORT]; *and infra* § II.C.

15. *See generally* 1986 ASSESSMENT REPORT, *supra* note 14, at 22-23; Stordal & Isakson, *Ozone Perturbations Due to Increases in N_2O, CH_4 and Chlorocarbons: Two-Dimensional Time-Dependent Calculations*, in 1 EFFECTS OF CHANGES IN STRATOSPHERIC OZONE AND GLOBAL CLIMATE 83 (J. Titus ed., 1986) (an EPA & UNEP study) [hereinafter 1986 OZONE & CLIMATE STUDY].

16. *See* 1986 ASSESSMENT REPORT, *supra* note 14, at 6-8; Stordal & Isakson, *supra* note 15, at 84; Kerr, *supra* note 2, at 785, 786.

17. This simple model is taken from Titus & Seidel, *Overview of the Effects of Changing the Atmosphere*, in 1986 OZONE & CLIMATE STUDY, *supra* note 15, at 4. *See also* Tolbert *et al.*, *Antarctic Ozone Depletion Chemistry: Reactions of N_2O_5 with H_2O and HCl on Ice Surfaces*, 240 SCIENCE 1018 (1988); Molina *et al.*, *Antarctic Stratospheric Chemistry of Chlorine Nitrate, Hydrogen Chloride, and Ice: Release of Active Chlorine*, 238 SCIENCE 1253 (1987); Tolbert *et al.*, *Reaction of Chlorine Nitrate with Hydrogen Chloride and Water at Antarctic Stratospheric Temperatures*, 238 SCIENCE 1258 (1988).

tions of a number of gases which affect atmospheric ozone.[18] These include CFCs, halons, methane, nitrous oxide, and carbon dioxide. The challenge, therefore, is to prevent further increase of these gases in the atmosphere. Additionally, since scientists have identified that the release of chlorine-and bromine-containing chemicals (CFCs and halons, respectively), for which human activities are responsible, threatens the stability of the ozone layer in the polar vortex,[19] the challenge is for decision makers to take appropriate preventive and remedial steps. The 1985 Vienna Convention for the Protection of the Ozone Layer,[20] the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer,[21] and the recent efforts to find substitutes for CFCs[22] are such steps. The pertinent question concerning the adequacy of these measures will be studied later.[23]

B. *Evidence of the Loss*

The major concern is with ozone loss in the stratosphere, which extends from about eight kilometers at the poles and 17 km at the equator to about 50 km above the earth's surface and is home to most of the ozone in the atmosphere.[24] Scientists have been studying changes both in the total column amount of atmospheric ozone and in its vertical distribution for over 30 years, using data from the ground-based Dobson spectro-photometer network, and since 1978, using data from NASA's Nimbus-7 satellite-based instruments, Solar Backscatter Ultraviolet (SBUV) and Total Ozone Mapping Spectrometer (TOMS), the Stratospheric Aerosol and Gas Experiment (SAGE) spectrometers, and the Solar Mesospheric Explorer (SME) spectrometers.[25] The first revelation that CFCs caused atmospheric ozone destruction was made in 1974, when two scientists, M.J. Molina and F.S. Rowland reported that "[p]hotodissociation of the chlorofluoromethanes in the stratosphere produces significant amounts of chlorine atoms and leads

18. *See supra* notes 10, 16.

19. *See generally* OZONE TRENDS PANEL REPORT, *supra* note 1, at 3,4,9.

20. Vienna Convention for the Protection of the Ozone Layer, March 22, 1985, *reprinted in* 26 I.L.M. 1516 (1987) [hereinafter Vienna Ozone Convention].

21. Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, *reprinted in* 52 Fed. Reg. 47515 (1987), and in 26 I.L.M. 1541 (1987) [hereinafter Montreal Protocol].

22. *See infra* notes 120-121 and accompanying text.

23. *See infra* notes 143-183 and accompanying text.

24. Watson, *Atmospheric Ozone*, in 1986 OZONE & CLIMATE STUDY, *supra* note 15, at 69.

25. *See* OZONE TRENDS PANEL REPORT, *supra* note 1, at 3, 16. A new ozone sensor, costing $5 million, to monitor changes in ozone concentrations, is now carried on a NOAA-11, a spacecraft launched on September 24, 1988. *See* Broad, *Satellite to Improve Monitoring of Ozone Loss*, N.Y. Times, Oct. 25, 1988, at B11, col. 1.

to destruction of atmospheric ozone."[26]

According to the 1988 International Ozone Trends Panel Report, there has been a measurable decrease in the average total column ozone of 1.7 to 3 percent "in all latitude bands from 30 to 64 degrees in the northern hemisphere from 1969 to 1986."[27] During the winter months, December through March, these decreases ranged from 2.3 to 6.2 percent.[28] Between 1978 and 1985, the TOMS satellite data showed a decline of total ozone column in all latitude zones, the range being 1.1 to 3.7 percent in the northern hemisphere, and 1.1 to 9 percent in the southern hemisphere.[29] The Panel has also reported the depletion in the vertical distribution of ozone during 1979 and 1985 to maximize near 40 km, from 5 to 12 percent.[30] The decrease over this time period is estimated at 4 to 9 percent in response to the increased abundance of trace gases, and only 1 to 3 percent in response to the reduced solar ultraviolet output.[31]

According to the Panel, there is evidence that natural events have significantly affected this recent trend.[32] These events include natural cycle geophysical changes such as the annual cycle of the seasons, the quasi-biennial oscillation of the stratospheric winds, the ll-year solar sunspot cycle, and natural effects of irregular transient phenomena, such as the El Nino Southern Oscillation or volcanic eruptions.[33]

The most dramatic discovery, however, was that of the Antarctic ozone hole, an unusual loss of 50 percent of ozone in the total column in the Antarctic springtime in 1987.[34] Data showed that, during the last decade, the loss of total column ozone over Antarctica in the springtime (September through November) had ranged between 30 and 40 percent.[35] In October 1987, the decline in ozone concentrations between 15 and 20 km was over 95 percent compared with their values in August 1987.[36]

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26. Molina & Rowland, *Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom-Catalyzed Destruction of Ozone*, 249 NATURE 810 (June 1974). *See also* Rowland & Molina, *Chlorofluoromethanes in the Environment*, 13 REV. GEOPHYS. SPACE PHYS. 1 (1975).

27. OZONE TRENDS PANEL REPORT, *supra* note 1, at 11.

28. *Id.*

29. *Id.* at 14.

30. *Id.* at 17.

31. *Id.*

32. *See id.*, at 11-13.

33. For earlier assessments, see 1986 ASSESSMENT REPORT, *supra* note 14, at 14-15.

34. OZONE TRENDS PANEL REPORT, *supra* note 1, at 86.

35. Bowman, *Global Trends in Total Ozone*, 239 SCIENCE 48 (1988).

36. OZONE TRENDS PANEL REPORT, *supra* note 1, at 18, 87. Dense stratospheric clouds form in the Antarctic and the ozone hole occurs within the polar vortex because of special conditions there, caused by weather, an isolated air mass, and very cold temperatures, which are pre-

Furthermore, scientists have found that, compared with October 1979, the monthly zonal mean amount of total ozone at latitudes 50, 60, 70, and 80 degrees south in October 1987, was about 8 percent, 20 percent, 40 percent, and 50 percent lower respectively.[37] It is estimated that during spring, there is now a 15 percent ozone depletion in southern Chile and Argentina compared with pre-1979 values.[38] According to TOMS data, total column ozone has declined since 1979 by over 5 percent at all latitudes south of 60 degrees throughout the year.[39]

In 1988, two reports by scientists, one based upon "long-term, ground-based observations,"[40] and the other upon TOMS data,[41] claimed springtime-level ozone losses during the polar winter as well. More recently, an arctic expedition which operated out of Norway from January 1 to February 15, 1989,[42] has confirmed the fear that the unusual, perturbed chemistry found in the Antarctic also occurs in the North Polar stratosphere.[43] It is also probable, based upon the existing analyses of global ozone data, that ozone losses are not confined to the polar regions.[44]

Predictions of ozone loss in the future vary, depending upon the chemical and atmospheric models used.[45] The discrepancy between prior predictions and actual depletions in column ozone, however, is noteworthy. Since 1969, at northern mid-latitudes, such depletions have been two to three times greater than those predicted.[46] Consequently, while scientists are uncertain whether the Antarctic ozone hole will spread over the southern hemisphere or the entire globe, and what its global ramifications are likely to be, decision makers have to

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requisites for perturbed chemistry. The reaction of chlorine under these conditions is especially destructive of ozone. *Id.*

37. *Id.* at 87.

38. *See* Stolarski & Schoeberl, 13 GEOPHYS. RES. LETTERS 1240 (1986).

39. OZONE TRENDS PANEL REPORT, *supra* note 1, at 98,99.

40. *See* Kerr, *supra* note 6, at 1145.

41. *See* Kerr, *supra* note 2.

42. Shabecoff, *Arctic Expedition Finds Chemical Threat to Ozone*, N.Y. Times, Feb. 18, 1989, at 1, col. 3.

43. *Id.* at 1, col. 4; 8, col. 2.

44. *See Stratospheric Ozone Depletion and Chlorofluorocarbons: Joint Hearings Before the Subcomms. on Environmental Protection, and Hazardous Wastes and Toxic Substances, of the Senate Comm. on Environment and Public Works*, 100th Cong., 1st Sess., at 6 (1987)(statement of Dr. F. Sherwood Rowland)[hereinafter STRATOSPHERIC OZONE DEPLETION AND CFCs]. *See also id.* at 34-41; Weisburd, *One Ozone Hole Returns, Another is Found*, 130 SCI. NEWS 215 (1986); *Ozone Hole Found over Europe*, NEW SCI., Oct 6, 1986, at 21.

45. *See* OZONE TRENDS PANEL REPORT, *supra* note 1, at 103-27; ASSESSING THE RISKS OF TRACE GASSES, *supra* note 10.

46. OZONE TRENDS PANEL REPORT, *supra* note 1, at 103.

weigh the risk of inadequate action, which in the long view might be very costly, against taking strong measures while scientific assessment is still continuing.

C. *Long-Term Consequences of Atmospheric Ozone Loss*

Depletion in the total column of stratospheric ozone (the amount of ozone found throughout the world)[47] would allow harmful solar ultraviolet radiation to penetrate to the surface of the earth, since ozone is the only gas in the atmosphere to provide a barrier to such radiation.[48] Additionally, were vertical distribution of atmospheric ozone to change, it could be a contributing factor in bringing about regional and perhaps global climatic changes.[49] Consequently, unless a proper balance of stratospheric ozone is maintained, adverse effects on human and animal health,[50] and harmful effects on plants[51] and aquatic systems[52] are likely to result from ultraviolet radiation exposure at the earth's surface.

Ultraviolet (UV) radiation is usually divided into three wave bands, UV-A, UV-B, and UV-C.[53] While UV-A is not carcinogenic at usual exposure levels, it causes most photosensitive reactions, that is, it exacerbates the symptoms of a number of skin diseases from sun exposure in those who are excessively sensitive to UV radiation.[54] These diseases include infectious diseases such as herpes simplex, altered metabolic states, nutritional deficiency states, and some hereditary genetic and immunologically-mediated diseases.[55] Although UV-A is not absorbed by ozone, it is reflected back to space, away from the earth's surface.

UV-C, which can cause skin and eye cancers and skin inflamma-

47. If compressed to the pressure at the earth's surface, the layer of ozone would be about one eighth of an inch thick. Watson, *supra* note 24.

48. *See* Frederick, *The Ultraviolet Radiation Environment of the Biosphere*, in 1986 OZONE & CLIMATE STUDY, *supra* note 15, at 121.

49. *See* Hansen, *et al.*, *The Greenhouse Effect: Projections of Global Climate Change*, in *id.* at 199.

50. *See, e.g.*, U.S. ENVIRONMENTAL PROTECTION AGENCY, ULTRAVIOLET RADIATION AND MELANOMA (Office of Air and Radiation, 1987); *see* Frederick, *supra* note 48, at 121; Emmett, *Health Effects of Ultraviolet Radiation*, in 1986 OZONE & CLIMATE STUDY, *supra* note 15, at 129; Wexler, *Ozone Depletion and Ocular Risks From Ultraviolet Radiation*, in *id.* at 147.

51. *See* Teramura, *Overview of Our Current State of Knowledge of UV Effects on Plants*, in *id.* at 165.

52. *See* Worrest, *The Effect of Solar UV-B Radiation on Aquatic Systems: An Overview*, in *id.* at 175.

53. *See* Emmett, *Health Effects of Ultraviolet Radiation*, in *id.* at 129.

54. *See id.* at 138.

55. *Id.* at 137.

tions, is at present almost all absorbed by stratospheric ozone.[56] UV-B is at present partially absorbed by ozone, and its exposure is of greatest concern since it is usually responsible for sunburn and skin cancer, and has potentially adverse effect on the body's immune system.[57] Thus, the effectiveness of this shield is likely to be reduced if levels of ozone continue to decline in the future.

Although other factors, including exposure to solar radiation, individual susceptibility, personal behavior, and land elevation,[58] also influence the nature and gravity of chronic effects of ultraviolet radiation, it is estimated that every one-percent decrease in total column ozone in the atmosphere results in a two-percent increase in UV-B radiation, causing in turn an increase of 4.8 to 7.6 percent incidence of nonmelanoma skin cancer.[59] Based upon the expected growth of trace gases it is estimated that even a moderate percent annual growth in current CFC emissions would lead to an increased incidence of nonmelanoma skin cancer cases in the United States of approximately 153 million people, which includes people alive today and born by the year 2075. Assuming that no advancement in medical technology takes place, this increase could lead to 3 million deaths resulting from nonmelanomas in the same time period. Also, given the same assumptions, additional melanoma skin cancer cases would increase by approximately 782,100, and the number of resulting deaths would be approximately 187,000 for the U.S. population alive today and born by the year 2075.[60]

While potential increased incidence of skin cancer is an area of major concern, changes caused by longterm exposure to UV radiation in the cornea, ocular lens, and retina are three main areas of concern for adverse effects on the eye.[61] Since both UV-B and UV-A are able to penetrate the interior of the eye, they both can damage the eye. Potential health problems include cataracts, stable vertical disorders, retinal degeneration, and aging and developmental disorders.[62] It is estimated that the number of cataracts cases, for the United States population alive today and born by the year 2075, would increase by 18.2 million based upon a moderate growth rate for current CFC

56. *Id.* at 130.

57. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 42; Shell, *supra* note 3, at 143.

58. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 5, 126, 143.

59. *Id.* at 35, 44; 52 Fed. Reg. 47494 (1987)(to be codified at 40 C.F.R. pt.82).

60. 52 Fed. Reg. 47494-95 (1987).

61. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 46.

62. *See* Wexler, *supra* note 50, at 147-48.

levels.[63]

After screening about 200 species of plants and different varieties within species, scientists have found that two out of every three plants tested showed some degree of UV sensitivity.[64] UV-irradiated plants suffer from reduced leaf areas, plant stunting, a reduction in total dry weight of the plant, and increased plant diseases.[65] Thus, future ozone depletion could adversely affect the world's food supplies.

Harmful effects of UV-B radiation on marine organisms and the marine food web include damage to fish larvae and juveniles, shrimp larvae, crab larvae, and other small animals and plants which are essential to sustain the marine food chain.[66] The long term result could be an unstable ecosystem, and an adverse effect on higher levels of the food chain, such as shell fish and fin fish.[67] The conclusion is inescapable that future ozone depletion would drastically affect the world's food supplies.

The United States Environmental Protection Agency's (EPA) statement of December 14, 1987, provides an apt conclusion: "Based on the WMO [World Meteorological Organization] assessment and EPA's recently completed risk assessment, the Agency believes that the current rate of growth in atmospheric levels of ozone-depleting gases is likely to result in substantial depletion of ozone which would lead to significant harm to human health and the environment."[68]

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63. 52 Fed. Reg. 47495 (1987). To mitigate the potential carcinogenic effects of increased UV radiation exposure, humans could perhaps take partially effective measures relying upon medical advancement and adapting their lifestyles to an increased UV intensity by using sunscreen and becoming more aware of the hazards of UV radiation. There are some scientists, however, who consider it unlikely that people will change their lifestyles in response to an increased UV radiation intensity. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 46.

64. *See* Teramura, *supra* note 51; STRATOSPHERIC OZONE AND CFCs, *supra* note 44, at 48-49.

65. *See* Teramura, *supra* note 51, at 170.

66. Zooplankton, which are tiny animals that drift in water and live primarily close to the surface of the water, would be exposed to UV radiation. Similarly, phytoplankton, which are tiny drifting plants and live near the water's surface in order to promote photosynthesis, would be exposed. Since almost every aquatic species relies directly or indirectly on these two plants for food, the food chain would be broken without these two planktons and the higher species which depend upon them for food would starve, thereby beginning the cycle of starvation through the aquatic food chain. Phytoplanktons and zooplanktons would probably swim deeper under water to escape the UV radiation, and since they are dependent upon sunlight, the likelihood is that they would grow less and thus would be of less nutritional value. *See* Worrest, *supra* note 52, at 179-83; STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 47; 52 Fed. Reg. 47495 (1987).

67. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 47.

68. 52 Fed. Reg. 47495 (1987).

D. *Policy Implications*

The ozone hole has presented a new set of challenges to the decisionmakers. As the scientists have found that atmospheric concentrations of ozone-modifying gases are on the rise,[69] and since the emissions from CFCs and halons liberate chlorine atoms in the stratosphere by chemical actions with UV radiation and cause ozone depletion,[70] policymakers are left with no option but to regulate the manufacture and use of ozone-depleting chemicals.

Table 1 shows a 5 percent annual increase since 1978 of CFC-11 and CFC-12 in the atmosphere, the former being used primarily as a foam-blowing agent and the latter being used primarily as a refrigerant in the United States. Abroad, however, both CFC-11 and -12 are also used as aerosol propellants. CFC-113, which is used primarily as a solvent by electronics and metal-cleaning industries, has had a ten percent annual increase in the atmosphere during the same period.

These increases reflect both continued emissions of CFCs during this period and also the long atmospheric lifetimes of these chemicals, (about 75 years for CFC-11 and about 120 years for CFC-12).[71] Thus, it is clear that the existing atmospheric levels of CFCs would decrease very slowly, even if emissions were reduced considerably, because the very long lifetimes of these chemicals would ensure they will continue to be added to the atmosphere much faster than they are destroyed. It is estimated that, other things being equal, such as atmospheric temperatures, it would take an immediate 85 percent emissions reduction to stabilize CFC and ozone concentrations.[72]

Crucial questions for policymakers relate to the nature of regulations on the manufacture and use of ozone-depleting chemicals and the efficacy of their implementation. A detailed discussion of these questions follows. In a summary fashion, however, it should be noted that the drafting of the 1985 Vienna Convention[73] and subsequently the 1987 Montreal Protocol[74] attest to the selection of a formal multilateral treaty route to accomplish the objective of bringing about emissions reduction. The treaty route was appropriate, for the problem

69. *See* Table 1, *infra* note 145. *See also supra* note 10.

70. *See supra* notes 10, 16.

71. *See* STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 5 (Statement of Dr. F. Sherwood Rowland).

72. *See* U.S. ENVIRONMENTAL PROTECTION AGENCY, AN ASSESSMENT OF THE RISKS OF STRATOSPHERIC MODIFICATION (Office of Air And Radiation, 1986).

73. *See* Vienna Ozone Convention, *supra* note 20.

74. *See supra* note 21.

could not have been addressed effectively in an informal manner through measures such as information exchanges and technical aid.

As to the nature of regulations, control measures have been prescribed on both production and consumption of selected chemicals.[75] However, even before the entry into force of these control measures, they are found wanting in their ability to effectuate the prevention of further ozone depletion.[76] Thus, a further strengthening of these prescriptive measures is in order. The control measures provide built-in flexibility to address special situations, such as those of developing countries.[77]

Implementation in the international arena always raises difficult questions. In the setting of a multilateral convention, even when the prescriptions are unambiguous and parties are clearly aware of their obligations and rights as well as of the available remedies under the agreement, how is the international community to ensure effective implementation? The first requirement, of course, is that there be wide ratification of the instrument. The second is that an effective institutional structure be in place to inform, oversee and monitor; to invoke and apply the norms; and to provide the available remedies. The third is that appropriate procedures be established to provide reasonable access to those invoking the agreement. The fourth is that there be sufficient incentives and penalties to encourage observance. The fifth requirement is that there be a compulsory dispute-settlement mechanism provided under the agreement.

As the following discussion will show, some of these requirements are met under the Montreal Protocol, but others have yet to be worked out. To illustrate, the parties are to establish institutional mechanisms and procedures to determine noncompliance at their first meeting after the Protocol goes into effect in 1989.[78] Also, the Protocol does provide for trade restrictions as a tool to enforce compliance,[79] although its thrust is on voluntary compliance. There are numerous loopholes in the control measures which the parties must address when they convene.[80] Another equally critical question is whether the policy undertaken would provide the needed incentives for the development and deployment of safe chemicals as replacements and substitutes for the CFCs and halons.

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75. *See infra* notes 146-157 and accompanying text.

76. *See infra* notes 196-206 and accompanying text.

77. *See* Montreal Protocol, *supra* note 21, art. 5.

78. *Id.*, art. 8.

79. *Id.*, art. 4.

80. *See infra* note 76.

III. INTERNATIONAL ENVIRONMENTAL LAW PRIOR TO THE 1985 VIENNA CONVENTION

The dearth of effective international norms and mechanisms to address questions of global environment, especially its management, is a reflection of the horizontal nature of the world community, which generally lacks a centralized authority to prescribe norms. Consequently, until recently, efforts toward environmental management have been sporadic and ineffectual and the development of international environmental law has been slow and its role rather limited, even though the need for international cooperative measures to control international environmental degradation, which respects no political boundaries, has been apparent.[81] Early transnational environmental efforts found expression either in a limited number of diplomatic and arbitral cases,[82] or in a number of weak international treaties in a limited area of conservation issues such as the protection of whales or migratory birds.[83]

In managing international rivers, however, the maxim *sic utere tuo ut alienum non laedas* (use your own property so as not to injure the property of another) has been generally applied for a long time.[84] By the early 1970s, there were over twenty institutional arrangements and over 300 bilateral conventions covering the rivers of the world.[85] Also, by the late 1960s, a proliferation of bilateral, regional, and multilateral conventions on several environmental issues, such as oil pollution on the high seas, nuclear transportation, waste disposal, river pollution, endangered species, weather modification and transboundary air pollution were negotiated.[86] There was, however, little coordinated effort to meet the global environmental challenge.

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81. *See generally* UNEP, *Environmental Law: An In-Depth Review* 5-6 (UNEP Rep. No. 2, 1981) [hereinafter UNEP Rep. No. 2].

82. These include the 1938/1941 Trail Smelter Case(U.S. v. Can.), 3 R. Int'l Arb. Awards 1905, 1965 (1949); Corfu Channel Case (Merits) (U.K. v. Alb.), 1949 I.C.J. 4, in which the International Court of Justice stated a "general and well-recognized" principle of international law under which it is "every State's obligation not to allow knowingly its territory to be used for acts contrary to the rights of other States." *Id.* at 22; 1954 Japanese Fisherman Case (U.S. responsibility for nuclear tests); 1957 Lake Lanoux Arbitration (French-Spanish river pollution dispute); 1958 Pacific Tests Case (U.S. nuclear tests); 1961 Ciudad Juárez Case (U.S. responsibility for river pollution); and 1973 Nuclear Tests Case (France's responsibility in South Pacific). For a detailed discussion, *see* Nanda, *The Establishment of International Standards for Transnational Environmental Injury*, 60 IOWA L. REV. 1089, 1095-1101 (1979).

83. *See* UNEP Rep. No. 2, *supra* note 81, at 5.

84. *See generally* Nanda, *Emerging Trends in the Use of International Law and Institutions for the Management of International Water Resources*, 6 DEN. J. INT'L L. & POL'Y 239, 258-59 (1976).

85. *See Developments in the Field of Natural Resources — Water, Energy and Minerals — Technical Aspects of International River Basin Development*, U.N. Doc. E/C.7/35 at 13 (1972).

86. *See* U.N. Doc. UNEP/GC./Info. 5, and Supp. 1-4.

The first major international effort toward the realization of effective mechanisms for global environmental management was undertaken in 1972. The setting was the U.N. Conference on the Human Environment, which met in Stockholm[87] and was convened in response to the need for coordination of the various national, bilateral, regional, and multilateral environmental efforts. The conference resulted in the formulation and approval of principles and recommendations to serve as guidelines for the future conduct of states in environmental and developmental matters.[88]

Among the Principles contained in the Declaration of the Stockholm Conference, three are of special note. Principle 21 is a clear enunciation of a state's "responsibility to ensure that activities within . . . [its] jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[89] Principle 22 obligates states to cooperate in the further development of international environmental law on "liability and compensation" for victims of transnational pollution and other environmental damage. Another Principle explicitly refers to the emission of substances such as CFCs: "The discharge of toxic substances or of other substances and the release of heat, in such quantities and concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems."[90]

Several pertinent recommendations, especially those related to "[i]dentification and control of pollutants of broad international significance,"[91] are noteworthy. Governments are asked to "[c]arefully evaluate the likelihood and magnitude of climatic effects and disseminate their findings to the maximum extent feasible before" undertaking polluting activities, and to "[c]onsult fully other interested States when activities carrying a risk of . . . effects [on climate] are being contemplated or implemented."[92] Also, in another recommendation, the international community is asked to support large-scale testing programs "for evaluation of the environmental impact potential of

87. The report of the conference is contained in U.N. Doc. A/CONF. 48/14/Rev.1 (1973), *reprinted in* 11 I.L.M 1416 (1972).

88. For the first ten years of UNEP activities, *see* Nanda & Moore, *Global Management of the Environment: Regional and Multilateral Initiatives*, in WORLD CLIMATE CHANGE: THE ROLE OF INTERNATIONAL LAW AND INSTITUTIONS 93, 97-103 (V. Nanda ed. 1983) [book hereinafter cited as WORLD CLIMATE CHANGE].

89. For a thorough discussion of this Principle, see generally Sohn, *The Stockholm Declaration of the Human Environment*, 14 HARV. J. INT'L L. 423, 485-93 (1973).

90. 11 I.L.M., *supra* note 87, Principle 6, at 1418.

91. *See id.* at 1449-53, Recommendations 70-85.

92. *Id.* at 1449, Recommendation 70.

specific contaminants or products,"[93] and a monitoring program to study "long-term global trends in atmospheric constituents and properties which may cause changes in meteorological properties, including climatic changes."[94]

For the purpose of the present study, the Stockholm Conference's major contribution lies in providing a concrete expression to growing international environmental concerns, which were vividly described in the Club of Rome's controversial study, *The Limits to Growth*.[95] The Conference led to the establishment of permanent institutions, including the United Nations Environment Programme (UNEP),[96] whose task is to coordinate the various activities pertaining to the "Action Plan" the Conference adopted, encompassing environmental assessment, environmental management, and supporting measures.[97] It is under the auspices of UNEP, which has acted as a catalyst, that international efforts have been mounted to address the ozone-depletion problem.[98]

The Conference Principles and Recommendations spurred further action by UNEP[99] and nations,[100] as well as regional organizations.[101] In 1974, Organization for Economic Cooperation and Development (OECD) adopted principles concerning transfrontier air pollution, which included the principles of notification and consultation; equal access to foreign nationals to seek administrative and judicial remedies

93. *Id.* at 1450, Recommendation 74(d)(ii).

94. *Id.* at 1452, Recommendation 79(a).

95. *See* D.H. MEADOWS, D.L. MEADOWS, J. RANDERS, W. BEHRENS, THE LIMITS TO GROWTH (Report to the Club of Rome, 1972). The study painted a grim picture of humanity's future because of growing environmental degradation.

96. *See* G.A. Res. 2997, 27 U.N. GAOR Supp. (No. 30) at 43, U.N. Doc. A/8730 (1972).

97. *See* 11 I.L.M., *supra* note 87, § II(A) at 1421. (Framework for the Action Plan for environmental action.)

98. *See, e.g., infra* note 142 and accompanying text; and especially STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 57 (statement of Dr. Mostafa K. Tolba, Executive Director, UNEP).

99. *See generally*, Sand, *Environmental Law in the United Nations Environment Programme*, in HAGUE ACADEMY OF INTERNATIONAL LAW/U.N. UNIVERSITY, THE FUTURE OF THE INTERNATIONAL LAW OF THE ENVIRONMENT 51 (R. Dupuy ed. 1985).

100. *See generally Ten Years After Stockholm — International Environmental Law*, 77 PROC. AM. SOC'Y INT'L L. 411-35 (1983), especially *id.* at 412 (enhanced state interest in environmental issues after Stockholm); Developments, *The United Nations Environmental Programme After a Decade: The Nairobi Session of a Special Character, May 1981*, 12 DEN. J. INT'L L. & POL'Y 269 (1983); Wood, *The United Nations World Charter for Nature: The Developing Nations' Initiative to Establish Protections of the Environment*, 12 ECOLOGY L.Q. 977 (1985). For a recent survey of environmental laws of a few selected countries in the EEC, Japan, and Mexico, *see* Smith & Falzone, *Foreign Environmental Legal Systems — A Brief Review*, 11 Int'l Env't Rep. (BNA) Curr. Rep. at 621 (Nov. 9, 1988).

101. For example, in 1973, the European Economic Community adopted its own program of action on the environment. *See* Declaration on the Environmental Action Program, 16 O.J. EUR. COMM. (No. C 112) at 1 (1973), *reprinted in* 13 I.L.M. 164 (1974).

as to a state's subjects; and non-discrimination, requiring states to control transboundary pollution as stringently as pollution remaining within the state.[102] In 1979, the Economic Commission for Europe (ECE) succeeded in achieving the adoption of the Convention on Long-Range Transboundary Air Pollution at Geneva,[103] which obligates contracting parties to consult upon request concerning activities affecting or posing a "significant risk" of long-range transboundary air pollution, and provides for information exchange and continued monitoring of pollutants, as well as collaborative research toward the objective of mitigating sulphur dioxide emissions.[104]

The International Law Commission adopted in 1976 its Draft Articles on State Responsibility.[105] One article lists the serious breach of an international obligation of essential importance for the safeguarding and preservation of the human environment, such as those prohibiting massive pollution of the atmosphere or of the seas, as an international crime.[106] The Commission continues to develop rules of international environmental law.[107] Among scholarly organizations, the work of the International Law Association[108] and the American Law Institute[109] deserve special mention.

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102. *See generally* OECD, A TENTATIVE ANALYSIS OF SOME DATA CONCERNING LONG-RANGE TRANSPORT OF AIR POLLUTANTS IN EUROPE 58 (1978), OECD Doc. ENV/TFP/78; OECD, LEGAL ASPECTS OF TRANSFRONTIER POLLUTION (1977); OECD, THE POLLUTER PAYS PRINCIPLE (1975); OECD, ENVIRONMENTAL POLICIES FOR THE 1980S (1980); OECD, NON-DISCRIMINATION IN RELATION TO TRANSFRONTIER POLLUTION: LEADING OECD DOCUMENTS 35 (1978) (on financing the monitoring and evaluation of air pollutants in Europe).

103. T.I.A.S. No. 10541 (November 13, 1979), *reprinted in* 18 I.L.M. 1142 (1979).

104. *See id.* arts. 4-7, 9. *See generally* Wetstone & Rosencranz, *Transboundary Air Pollution: The Search for an International Response*, 8 HARV. ENV'L L. REV. 89, 100-106 (1984).; Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution, on Financing the Monitoring and Evaluation of Air Pollutants in Europe, September 28, 1984, *reprinted in* 24 I.L.M. 484 (1985).

105. 31 U.N. GAOR Supp. (No. 10) at 170, U.N. Doc. A/31/10 (1976), *reprinted in* [1976] 2 Y.B. INT'L L. COMM'N 73, U.N. Doc. A/CN.4/Ser.A/1976/Add.1.

106. *Id.* art. 19(3)(d).

107. It continues to work on the two topics it has had under consideration for many years: "The Law of Non-Navigational Uses of International Water Courses," and "International Liability For Injurious Consequences Arising Out of Acts Not Prohibited by International Law." *See Report of the International Law Commission on the Work of Its Thirty-Ninth Session*, 42 U.N. GAOR Supp. (No. 10) at 33, 89, U.N. Doc. A/42/10 (1987). *See also* McCaffrey, *The Work of the International Law Commission Relating to the Environment*, 11 ECOLOGY L.Q. 189 (1983); McCaffrey, *An Update on the Contributions of the International Law Commission to International Environmental Law*, 15 ENV'L L. 667 (1985).

108. *See, e.g., Legal Aspects of Long-Distance Air Pollution*, in INTERNATIONAL LAW ASSOCIATION, REPORT OF THE SIXTY-SECOND CONFERENCE (SEOUL) 198 (1987); and *Water Resources Law* in *id.* 231.

109. *See generally* RESTATEMENT (THIRD) OF THE FOREIGN RELATIONS LAW OF THE UNITED STATES Pt. VI (1987), especially § 601(1). *See also id.* § 601(2), comment e; § 601 reporter's note no. 1 (general principles of state responsibility for environmental injury), no. 4 (obligation to notify and consult), and no. 9 (impact abroad upon the "global commons"). *See id.* § 602 (remedies for violation of environmental obligations.).

The major significance of the recent developments is that, in addition to the establishment of substantive norms of international environmental law on specific issues such as transboundary air pollution,[110] marine pollution,[111] and utilization of international waters,[112] several procedural norms have emerged, which have been gaining general acceptance. These include a state's duty to cooperate, to notify, to exchange information, to consult and negotiate regarding activities on its territory which may have extraterritorial environmental effects,[113] and the emerging regime of equal right of access and non-discrimination under OECD guidelines.[114]

IV. EVENTS LEADING TO THE 1985 VIENNA CONVENTION AND THE 1987 MONTREAL PROTOCOL

The 1974 report by Molina and Rowland on the destruction of ozone by CFCs[115] was followed by two reports released by the National Academy of Sciences (NAS) in September 1976 on the emissions of chlorofluoromethanes and the associated health and biological effects of such emissions.[116] The NAS sounded an ominous warning:

110. *See* notes 102-104 *supra* and accompanying text.

111. *See generally* RESTATEMENT (THIRD) OF THE FOREIGN RELATIONS LAW OF THE UNITED STATES §§ 603-604 (1987); U.N. Convention on the Law of the Sea, Dec. 10, 1982, at arts. 192-237, *reprinted in* 21 I.L.M. 1261 (1982) and The Law Of the Sea, Official Text of the United Nations Convention on the Law of the Sea with Annexes and Index (U.N. Sales No. E.83 V.5 (1983); Nanda, *Protection of the Internationally Shared Environment and the United Nations Convention on the Law of the Sea*, in CONSENSUS AND CONFRONTATION : THE UNITED STATES AND THE LAW OF THE SEA CONVENTION 403 (J. Van Dyke ed. 1985).

112. *See supra* notes 84-85, 107 and accompanying text.

113. In addition to notes 102-109 *supra*, *see generally* OECD, OECD AND THE ENVIRONMENT 106-26 (1979); G.A. Res. 2995, 27 U.N. GAOR Supp. (No. 30) 42 (1972); U.N. Doc. A/CN. 4/402, para. 14 (1986)(Report of J. Barboza to the International Law Commission.); U.N. Survey of State Practice Relevant to International Liability for Injurious Consequences Arising Out of Acts Not Prohibited by International Law 180-182, U.N. Doc. A/CN. 4/384 (1984); Bothe, *Transfrontier Environmental Management*, in INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES, TRENDS IN ENVIRONMENTAL POLICY AND LAW 391 (1980); OECD, RECOMMENDATIONS OF THE COUNCIL ON WATER MANAGEMENT POLICIES AND INSTRUMENTS, Paris, Apr. 5, 1978, No. 7, OECD Doc. C. (78) 4 (Final); Bothe, *International Legal Problems of Industrial Siting in Border Areas and National Environmental Policies*, in OECD, TRANSFRONTIER POLLUTION AND THE ROLE OF STATES 79, 85-92, 95-97 (1981).

114. *See, e.g.*, OECD, *Recommendation of the Council for Implementation of Regime of Equal Right of Access and Non-Discrimination in Relation to Transfrontier Pollution*, May 17, 1977, OECD Doc. C. (77) 28 (Final (1977) (see especially Annex, Introduction, sub-para. (a)); OECD, OECD AND THE ENVIRONMENT 115-16 (1979); OECD, *1974 Recommendation for Equal Right of Access in Relation to Transfrontier Pollution*, OECD Doc. C (76) 55 (1976); Scandinavian Convention on the Protection of the Environment, 1974, art. 11, *reprinted in* 13 I.L.M. 591, 595 (1974).

115. *See supra* note 26.

116. NATIONAL ACADEMY OF SCIENCES (NAS), HALOCARBONS: EFFECTS ON STRATOSPHERIC OZONE (1976); NAS, HALOCARBONS: ENVIRONMENTAL EFFECTS OF CHLOROFLUOROMETHANE RELEASES (1976).

"Selective regulation of CFM uses and releases is almost certain to be necessary at some time and to some degree of completeness."[117] However, the study noted that at that time "[n]either the needed timing or the needed severity can be reasonably specified."[118] The following month, several U.S. federal agencies announced a proposed reduction over the next 18 months in the uses of certain CFCs in aerosol sprays.[119]

The NAS followed its 1976 studies by two more studies in 1979[120] and several more in the 1980s.[121] The message was clear that continued use of CFCs could cause substantial depletion of ozone. The United States Environmental Protection Agency issued in October 1980 an Advance Notice of Proposed Rulemaking, which discussed the subject of an immediate freeze on the production of some CFCs and the possibility of using a system of marketable permits for the allocation of CFC consumption among those industries which use CFCs.[122]

It is important to note that the United States was not alone in conducting the studies, sounding the warning, and taking some action. Others engaged in such activities were primarily the European states, which individually and also in agreements with other states, acted to regulate the use of CFCs.[123]

Internationally, UNEP and WMO took the initiative and actively pursued the issue starting in the early 1980s, conducting studies and a series of workshops.[124] Negotiations to resolve differences between the

117. NAS, HALOCARBONS: ENVIRONMENTAL EFFECTS OF CHLOROFLUOROMETHANE RELEASES 7 (1976).

118. *Id.*

119. *See* STRATOSPHERIC OZONE DEPLETION & CFCs, *supra* note 44, at 63, 66 (statement of F. Sherwood Rowland in which he notes this development). For the U.S. action banning the use of CFCs in aerosols by 1978, see Toxic Substances Control Act, 15 U.S.C. §§ 2601-2629 (1976).

120. *See* NAS, PROTECTION AGAINST DEPLETION OF STRATOSPHERE OZONE BY CHLOROFLUORCARBONS (1979); NAS, STRATOSPHERIC OZONE DEPLETION BY HALOCARBONS: CHEMISTRY AND TRANSPORT (1979).

121. *See* NAS, CHANGING CLIMATE (1983); NAS, CAUSES AND EFFECTS OF CHANGES IN STRATOSPHERIC OZONE: UPDATE 1983 (1984). For an important study by NASA, *see* 1986 ASSESSMENT REPORT, *supra* note 14. Another study of note is by EPA, see OZONE TRENDS PANEL REPORT, *supra* note 1.

122. *See* 45 Fed. Reg. 66,726 (1980).

123. *See, e.g.*, Weiss, *A Resource Management Approach to Carbon Dioxide During the Century of Transition*, in WORLD CLIMATE CHANGE, *supra* note 88, at 167, 184-85; Agreement Among the United States, France, and the United Kingdom, 27 U.S.T. 1437, T.I.A.S. No. 8255, *reprinted in* 1 Int'l Env't Rep. (BNA) § 21: 2501 [1978 Reference File]; Sand, *Protecting the Ozone Layer: The Vienna Convention is Adopted*, ENVIRONMENT, June 1985, at 18, 41.

124. *See generally* UNEP Rep. No. 2, *supra* note 81, at 15; UNEP, *Program Performance Report — Addendum*, UNEP/GC. 10/5 Add. 2, at 2-4 (Dec.7, 1981); UNEP, *Nowhere to Hide*, in STRATOSPHERIC OZONE DEPLETION AND CFCs, *supra* note 44, at 57 (statement by Dr. Mos-

United States, which sought stricter controls, and several of its trading partners, which favored more lax standards and controls,[125] culminated in the adoption of the 1985 Vienna Convention and the 1987 Montreal Protocol.

V. The 1985 Vienna Convention and Negotiations Toward the 1987 Montreal Protocol

Eventually, in March 1985, a diplomatic conference adopted the Vienna Convention for the Protection of the Ozone Layer.[126] Recalling Principle 21 of the U.N. Conference on the Human Environment and the World Plan of Action on the Ozone Layer of UNEP,[127] the Convention promotes global cooperation necessary to protect the ozone layer. It established a framework for concerted action in the future, while limiting itself to providing general measures for international cooperation in research, monitoring, and information exchange. No concrete obligations were undertaken by states to limit the production or use of chemicals that deplete ozone, but the Convention envisaged further negotiations and adoption of necessary international regulatory measures in the future.

Thus, although the Convention did not specify strategies, the parties would be obligated to cooperate in several ways: (1) to adopt appropriate legislative and administrative measures; (2) "in harmonizing appropriate policies to control," limit, reduce, or prevent human activities under their jurisdiction or control that adversely affect the ozone layer; (3) "in the formulation of agreed [implementation] measures,

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tafa K. Tolba, Executive Director, UNEP) [hereinafter *Nowhere to Hide*]; Sand, *supra* note 123, at 40-43; UNEP/GC. 8/70 (Apr. 29, 1980); UNEP/GC. 13/16 (1985); Benedick, *International Cooperation to Protect the Ozone Layer*, 86 DEP'T ST. BULL., June 1986, at 58; Benedick, *Protecting the Ozone Layer*, 85 *id.*, Apr. 1985, at 63; M. TOLBA, THE STATE OF THE WORLD ENVIRONMENT: THE 1980 REPORT OF THE EXECUTIVE DIRECTOR OF THE UNITED NATIONS ENVIRONMENT PROGRAM (1980); *The State of the World Environment, 1972-1982*, UNEP/GC (SSC)/INF. 2 (Jan. 29, 1982); Taubes & Chen, *Made In The Shade?*, DISCOVER, Aug. 1987, at 62; World Meteorological Organization, *Atmospheric Ozone: 1985 — Assessment of Our Understanding of the Processes Controlling Its Present Disruption and Change* (Global Ozone and Monitoring Project, Rep. No. 16, 1986); Wasermann, *UNEP: Protection of the Ozone Layer*, 17 J. WORLD TRADE L. 182 (1983).

125. UNEP's legal adviser, Rummel-Bulaska, discusses the negotiations leading to the adoption of the convention in Rummel-Bulaska, *The Protection of the Ozone Layer Under the Global Framework Convention*, in TRANSBOUNDARY AIR POLLUTION 281 (C. Flinterman ed. 1986). *See also* UNEP, *Nowhere to Hide*, *supra* note 124; Benedick, *International Cooperation to Protect the Ozone Layer*, *supra* note 124; Sand, *supra* note 123, at 41-42; Lang, *Environmental Protection — The Challenge for International Law*, 19 J. WORLD TRADE L. 489, 492 (1985); 10 Int'l Env't Rep. (BNA), Curr. Rep. 195-96 (May 13, 1987); *id.* at 273 (June 10, 1987); *id.* at 315-16 (July 8, 1987); *id.* at 451 (Sept. 9, 1987).

126. *See generally* Vienna Ozone Convention, *supra* note 20; UNEP, U.N. Doc. UNEP/IG 53/3,4 and 5/Rev. 1 (1985).

127. *See* Vienna Ozone Convention, *supra* note 20, preamble.

procedures, and standards;" and (4) "with competent international bodies to implement effectively this Convention and protocols to which they are party."[128] The parties also undertook the obligation "to initiate and cooperate in, directly or through competent international bodies, the conduct of research and scientific assessments" on processes that may affect the ozone layer and on effects of modifications of the ozone layer.[129] Similarly, the parties agreed to promote or establish joint or complementary programs "for systematic observation of the state of the ozone layer," and to cooperate "in ensuring the collection, validation and transmission of research and observational data . . . in a regular and timely fashion."[130]

Other obligations include those to cooperate in the legal, scientific, and technical fields,[131] and to transmit pertinent information on the measures adopted by them in implementation of the Convention[132] to the Conference of the Parties, which was established under the Convention.[133] The Convention also established a secretariat[134] and a dispute-settlement procedure, which includes negotiation, good offices, mediation, and conciliation, but does not obligate parties to resort to arbitration or litigation before the International Court of Justice if a settlement is not reached through negotiation or mediation.[135]

Although the Convention failed to provide for controls on the manufacture or use of ozone-depleting chemicals, it was a promising first step, for it signified recognition by the world community that it must act promptly on this environmental challenge before the occurrence of any actual damage. The remarks of Dr. Mostafa K. Tolba, the Executive Director of UNEP are pertinent:

> This is the first global convention to address an issue that for the time being seems far in the future and is of unknown proportions. This Convention, as I see it, is the essence of the anticipatory response so many environmental issues call for: to deal with the threat of the problem before we have to deal with the problem itself.[136]

The period between the signing of the Vienna Convention and the adoption of the Montreal Protocol was still marked by a continuing

128. *Id.*, art. 2, para.2.

129. *Id.*, art. 3, para.1.

130. *Id.*, art. 3, paras. 2-3.

131. *Id.*, art. 4.

132. *Id.*, art. 5.

133. *Id.*, art. 6.

134. *Id.*, art. 7.

135. *Id.*, art. 11.

136. Excerpt from Dr. Tolba's statement at the Vienna Convention, *reprinted in* Sand, *supra* note 123, at 20.

debate on whether CFCs and trace gases are responsible for the depletion of ozone or if such depletion could be attributed to natural atmospheric variations.[137] Those believing in the dynamical theory of the ozone hole, continued to argue that there was still uncertainty about the effects of the chlorine in the stratosphere.[138] In the meantime, studies and further negotiations continued.[139] At a Senate hearing in May 1987, David Doniger, Senior Attorney at the Natural Resources Defence Counsel stated:

> We should all remember that the 95% phase-down policy [for CFCs and 2 halons in 10-14 years] was developed on the basis of a broad scientific analysis, but without taking into account such phenomena as the passive and unexpected Antarctic ozone hole. As Ambassador Richard Benedick [chief U.S. negotiator] stated at a CFC conference on March 25, "[w]e have simply excluded that disturbing phenomenon from our equations." Now, however, scientists from the National Ozone Expedition who have directly investigated the causes of the Antarctic hole have testified that it is probably linked to CFCs. While many scientific issues remain to be explored, these developments reinforce an inevitability of the 95% phase-down policy for policymakers with any sense of prudence in the face of potentially catastrophic global consequences.[140]

Earlier, the U.S. Environmental Protection Agency (EPA) released a report in 1986 on an assessment of the risks of stratospheric modification.[141] Eventually, UNEP's efforts, with active participation and support of the United States, succeeded as the negotiations culminated in the adoption of the Montreal Protocol.[142]

VI. THE 1987 MONTREAL PROTOCOL

On September 16, 1987, 24 states signed the Montreal Protocol on Substances that Deplete the Ozone Layer, which expanded the purpose of the Vienna Convention by upholding a state's obligation "to

137. *See generally* Taubes & Chen, *supra* note 124, at 68-69.

138. *See, e.g.*, STRATOSPHERIC OZONE DEPLETION AND CFCS, *supra* note 44, at 36-37 (statement of Dr. Adrian Tuck, Environmental Research Laboratories, National Oceanic and Atmospheric Administration, U.S. Department of Commerce).

139. *See Nowhere to Hide*, *supra* note 124; STRATOSPHERIC OZONE DEPLETION AND CFCS, *supra* note 44, at 472 (statement of Lee M. Thomas, administrator EPA), 475 (statement of Richard Benedick, Deputy Assistant Secretary for Environment, Health, and Natural Resources, Department of State), 477 (statement of Anthony Calio, Undersecretary of Commerce for Oceans and the Atmosphere, Department of Commerce); EPA, EFFECTS OF CHANGES IN STRATOSPHERIC OZONE AND GLOBAL CLIMATE (1986); Benedick, *International Efforts To Protect the Stratospheric Ozone Layer*, CURRENT POLICY No. 931 (U.S. Dep't State, Mar. 1987); note 272 *infra*.

140. STRATOSPHERIC OZONE DEPLETION AND CFCS, *supra* note 44, at 431, 433-34.

141. U.S. ENVIRONMENTAL PROTECTION AGENCY, AN ASSESSMENT OF THE RISKS OF STRATOSPHERIC MODIFICATION (Office of Air and Radiation 1986).

142. *See* Negroponte, *Montreal Protocol: Controlling Substances that Deplete the Ozone Layer*, 87 DEP'T ST. BULL., Dec. 1987, at 60, 61-62; *infra* note 210.

take appropriate measures to protect human health and the environment against adverse effects resulting or *likely to result* from human activities which modify or are *likely to modify* the ozone layer.[emphasis added]"[143] The recognition of scientific uncertainty, reflected in the phrases "likely to result" and "likely to modify," strengthens the position that action must be taken to avert a continuance of ozone depletion. The basis for such action must be the present state of scientific knowledge, with sufficient flexibility to change if dictated by future scientific data.[144]

It should be noted at the outset that the Protocol does not place limits on each of the controlled substances that are specified in it. It does place a separate limit on the total ozone depletion caused by Group I (five types of CFCs) and II (three types of halons) controlled substances[145] that a state party may produce and consume. It leaves up to each party how to stay within those limits.

A. *Control Measures Under the Protocol*

The Protocol states that as of July 1, 1989 (following the needed ratifications), annual levels of a party's production[146] and consumption[147] of controlled substances in *Group I* shall not exceed a party's

143. Montreal Protocol, *supra* note 21, Preamble (emphasis added to highlight the addition to the Preamble of the Vienna Convention) [hereinafter Protocol].

144. *See id.*, art. 2, paras. 9-10, art. 6 (sufficient flexibility is provided).

145. TABLE 1

CONTROLLED SUBSTANCES

Group I Substances	Ozone Depleting Potential*
$CFCl_3$ (CFC-11)	1.0
CF_2CL_2 (CFC-12)	1.0
$C_2F_3CL_3$ (CFC-113)	0.8
$C_2F_4Cl_2$ (CFC-114)	1.0
C_2F_5Cl (CFC-115)	0.6
Group II Substances	
CF_2BrCl (halon-1211)	3.0
CF_3Br (halon-1301)	10.0
$C_2F_4Br_2$ (halon-2402)	(to be determined)

* These ozone depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically.

Id. Annex A.

Different CFCs have different ozone depletion levels. CFC-11 and -12 have been assigned an ozone depletion level of 1.0. All other controlled substances have an ozone depletion level that corresponds with CFC-11 and -12 depletion levels. Thus a level less than 1.0 would have lower depletion effect than CFC-11 or -12.

146. This is the amount of controlled substances produced minus the amount destroyed by approved technologies. *Id.*, art. 1, para. 5.

147. This is production plus imports minus exports of controlled substances. *Id.*, art. 1, para. 6.

1986 level of production and consumption of *Group I* substances.[148] Two major exceptions exist. One exception allows up to a 10 percent increase in production, based upon 1986 levels, to satisfy the basic domestic needs of developing countries operating under article 5 of the Protocol. The other exception allows for a 10 percent increase above 1986 production levels for the purposes of "industrial rationalization"[149] between Parties. "Industrial rationalization" is an economic solution which would allow one party to transfer some or all of its level of production to another party to achieve economic efficiency or to meet anticipated shortfalls in supply because of plant closures. Thus, if one party does not use all of its controlled substances production allotment, that party may sell its rights to produce the controlled substances to another party which may have already reached its production level for the controlled substances for a particular year, and which wants to produce more.

It seems essential that the parties must determine the needed mechanisms for implementing industrial rationalization through a subsequent agreement within a short time after the Protocol enters into force. It is not desirable or appropriate to leave it to the economic marketplace to determine what controlled substances are produced, because a supply and demand mechanism is not concerned with, nor will it reflect, potential environmental impacts (external costs) which may result in a "tragedy of the commons."

An even more serious problem is that of setting production and consumption levels at 1986 base levels. Given the nature of our current scientific understanding, it seems clear that maintenance of such high levels (as existed in 1986) of production and consumption will allow the depletion levels to continue to increase well into the 21st century, with all of their potential deleterious effects. Moreover, how will the accuracy of the 1986 base year levels that each party has determined for itself be verified? Calculation and verification of 1986 control baseline levels will be difficult if accurate records are not available, thus adding uncertainty, because a party with a higher baseline would be economically better off than a party which sacrificed higher production levels. Also, the same verification and calculation problems may result every year when an accounting of production, consumption, export and import levels must be reported.[150]

As of July 1993, annual levels of production and consumption of

148. *Id.*, art. 2, para. 1.

149. *Id.*, art. 1, para. 8.

150. *Id.*, art. 7.

Group I controlled substances must not exceed 80 percent of a party's 6 levels of production and consumption.[151] Thus within five and one half years, *Group I* production and consumption levels must be reduced by only 20 percent of 6 baseline levels. The same percent potential production increase exceptions for domestic needs of developing countries and for industrial rationalization apply. These exceptions could further reduce the meager reductions that are to be instituted.

As of July 1, 1998, annual levels of production and consumption of controlled substances in *Group I* may not exceed 50 percent of a party's 1986 levels for *Group I* substances.[152] A 15 percent increase in production (over the 50 percent level) is allowed to satisfy the basic domestic needs of developing nations or for industrial rationalization. Thus, maximum world reductions in *Group I* substances will only be between 35 and 50 percent. Since our present scientific knowledge tells us that an immediate 85 percent of controlled substance usage is needed just to keep matters from worsening, the proposed reductions do not seem to be adequate to help reduce the present or future rates of ozone depletion. Furthermore, a two-thirds majority of the consuming parties can vote to eliminate this entire provision from the Protocol so that the 1993 levels would be the maximum reductions deemed necessary under this Protocol.[153]

Other exceptions to these levels of production include allowing a party whose 1986 level of production is less than twenty-five kilotons, for purposes of industrial rationalization, to transfer or receive production abilities in excess of the limits set for *Group I* substances during any time period, provided that the total combined production levels between parties do not exceed applicable production limits.[154] The language of this provision is ambiguous and could theoretically result in defeating or at least diluting the purpose of this Protocol. To illustrate, a developed country, such as the United Kingdom, could acquire the production rights of a developing country, such as Ghana,

151. *Id.*, art. 2, para. 3.

152. *Id.*, art. 2, para. 4.

153. *Id.*

154. *Id.*, art. 2, para. 5. Except for developing countries covered in Article 5, any Party which has contracted for or is constructing facilities to produce controlled substances prior to September 16, 1987, and has provided for the same in national legislation prior to January 1, 1987, may add the production capability from such facilities to its 1986 production base level, provided that such facilities are completed by December 31, 1990, and that such production does not raise a Party's annual level of consumption of the controlled substances above 0.5 kilograms per capita. This provision seems to cater to special interests, such as the Soviet Union and other countries with planned economies, so that a nation's or industry's initial investment of financing new production facilities is not lost. It could, however, lead to increases in production capability, which is not what the Protocol is designed to do.

to produce more CFCs than its allotted quota, so long as the total did not exceed applicable production limits of these two countries. Also, if the United Kingdom decided not to produce CFCs any more, it could transfer its quota to Ghana. Other exceptions involve facilities under construction or contract for production of controlled substances,[155] and the manner of implementation of the Protocol by states members of regional economic organizations, such as the European Economic Community.[156]

As of February 1, 1992, annual levels of production and consumption of controlled substances in *Group II* are not to exceed a party's 1986 levels of production and consumption of *Group II* substances.[157] The same exceptions exist for *Group II* as for *Group I* substances (up to a percent increase for both basic domestic need of developing nations and industrial rationalization). The stated objections applicable to *Group I* are also applicable here, with some additions. Is it really necessary or desirable to wait an additional two and a half years just to implement the 1986 baseline for production and consumption of *Group II* controlled substances, which have a much higher ozone depletion potential? This only delays the creation and implementation of alternatives to *Group II* substances. Furthermore, no additional decreases in production or consumption of *Group II* substances are dictated in the Protocol. Even though *Group II* substances are not produced and consumed at the rate of *Group I* controlled substances, more severe reductions are needed to reduce future risks of ozone depletion.

B. *Production Adjustments to the Protocol*

The Protocol provides for the parties to determine whether further adjustments[158] and reductions in production and consumption of the

155. *Id.*, art. 2, para. 6. According to the provision, except for developing countries covered in Article 5, any Party which has contracted for or is constructing facilities to produce controlled substances prior to September 16, 1987, and has provided for the same in national legislation prior to January 1, 1987, may add the production capability from such facilities to its 1986 production base level, provided that such facilities are completed by December 31, 1990, and that such production does not raise a Party's annual level of consumption of the controlled substances above 0.5 kilograms per capita. This provision seems to cater to special interests, such as the Soviet Union and other countries with planned economies, so that a nation's or industry's initial investment of financing new production facilities is not lost. It could, however, lead to increases in production capability, which is not what the Protocol is designed to do.

156. *Id.*, art. 2, para. 8.

157. *Id.*, art. 2, para. 2.

158. Article 6 of the Protocol requires that as of 1990 and every four years thereafter, the Parties will meet to assess the control measures and to determine progress in controlling ozone depletion. It is hoped that further reductions can be made at such meetings that will more effectively deal with the problems at hand.

controlled substances is deemed necessary.[159] It is important that the Protocol allows for further cuts in the future. As other nations fully understand the adverse consequences of this limited action approach to the ozone depletion problem or if science comes up with an even stronger cause-effect connection, it will be necessary to modify[160] the Protocol as required.

If all efforts at consensus have failed, an adjustment or modification may be adopted by a two-thirds majority vote of the parties that are present at such a meeting if the parties represent at least 50 percent of the total consumption of the controlled substances of all parties.[161] Such a decision would be binding upon all parties. Perhaps it would have been better if the "50 percent total consumption" was replaced by "50 percent of the total production" to ensure cooperation among producing countries to abide by the new adjustments if a reduction were required.

C. *Unilateral Measures*

The Protocol appropriately provides that parties may take more stringent measures than those required under it.[162] This is, however, unlikely for economic reasons. Unless all parties equally share the burdens of reduced production and consumption, some nations may wish to gain short-term profits by limiting their efforts to the levels specified in the Protocol, instead of instituting more severe restrictions.

D. *Developing Nations*

The Protocol recognizes that developing nations are not economically in a good position to make many sacrifices. Thus, it provides a grace period of ten years for the compliance of developing nations, which are identified as those whose annual level of consumption of controlled substances is less than 0.3 kilograms per capita on or before January 1, 1999.[163] The only limitation is that the developing nation's consumption level is not to exceed 0.3 kilograms per capita.

In order to try to reduce the need to produce such substances, the parties are to attempt to make alternative substances, technology, and

159. *See id.*, art. 2, para. 9.

160. This may require removing a controlled substance from the controlled list if it is found not to be a potential cause of ozone depletion. Two-thirds majority vote of present Parties would be needed for such a modification. *Id.*, art. 2, para. 10.

161. *See id.*

162. *Id.*, art. 2, para. 11.

163. *See id.*, art. 5.

subsidies aid available to developing nations.[164] It is true that developing nations have a lesser impact in production and consumption of controlled substances, but this exception still allows for significant growth rates in controlled substances production. It is noteworthy that among developing countries, India did not participate in the conference,[165] and the People's Republic of China did not sign the Protocol, although it did participate in the conference.[166] It is imperative that these two most populous countries equally share the concern of the developed countries about ozone depletion and become parties to the Montreal Protocol.[167]

E. *Import/Export Restrictions*

By January 1, 1990, each party must ban the import of controlled substances from any state not a Party to the 1987 Protocol.[168] This is important because import restrictions strengthen the Protocol and provide a disincentive for present producers of controlled substances to refuse to sign it.

By January 1, 1993, no party may export any controlled substances to a state not a party to the 1987 Protocol; parties are also discouraged from exporting technology to non-parties which is useful for utilizing controlled substances.[169] These provisions also provide an incentive for a state to sign the Protocol, especially if it is dependent upon foreign CFC production.

The Protocol further provides that by January 1, 1992, the Parties are to list products that contain controlled substances and ban their import within a year after that from any State that is not a Party to the 1987 Protocol.[170] This will further prevent nations from profiting by not being a part of the controlled substances reductions specified in the Protocol. Additionally, by January 1, 1994, the Parties are to determine the feasibility of banning or restricting, from States not Parties to the 1987 Protocol, the import of products produced with but not con-

164. *Id.*, art. 5, paras. 2-3.

165. *See* Weisskopf, *Nations Sign Agreement to Guard Ozone Layer*, Wash. Post, Sept. 17, 1987, § A, at 2, cols. 4, 6.

166. *Id.*

167. In early March 1989, over 120 countries met in a three-day conference on the protection of the ozone layer, convened by the British government in London from March 5-7. The purpose was to persuade non-parties to become parties to the Protocol. *See* Fin. Times (London), March 4, 1989, at 5; Whitney, *London Talks Hear Call for '97 Ban on Anti-Ozone Chemicals*, N.Y. Times, Mar. 6, 1989, at B10, col. 1.

168. Montreal Protocol, *supra* note 21, art. 4, para. 1.

169. *See id.*, art. 4, paras. 2, 5.

170. *Id.*, art. 4, para. 3.

taining controlled substances.[171] The Parties are also to refrain from financing exports to non-Parties of "products, equipments, plants, or technology that would facilitate the production of controlled substances."[172]

Economic disincentives or penalties such as trade restrictions can be highly persuasive tools for convincing nations to join the Protocol. The greatest reduction, within reason, in controlled chemical usage would be beneficial and should be encouraged. This will also encourage development of substitute processes so that controlled substances are no longer used in the manufacturing process. However, the development of substitutes which it is hoped will alleviate the current industrial dependence on controlled substances and effectively reduce their production, will itself depend upon the development of appropriate new technologies. Recent reports by the industry announcing the introduction of such technologies to develop substitutes for CFCs as well as to develop devices to capture and remove CFCs from automotive air conditioning systems, show great promise.[173]

F. *Noncompliance*

The Protocol requires that at their first meeting, presumably by January 1990, the parties must approve procedures and institutional mechanisms for determining noncompliance and treatment of noncompliant parties.[174]

In discussing compliance in the international arena, one must confront several special challenges. First, who has jurisdiction to hear compliance standards. Second, who has jurisdiction to hear compliance matters? The Protocol's predecessor, the 1985 Vienna Convention, states that parties engaged in disputes concerning the Convention (or subsequent protocols to the Convention) shall first seek solution by negotiation.[175] If a negotiated settlement is not reached, the parties may jointly seek the good offices of or request mediation by a third party.[176] A party may also declare in writing that, for a dispute not

171. *Id.*, art. 4, para. 4.

172. *Id.*, art. 4, para. 6.

173. *See, e.g.*, 11 Int'l Env't. Rep. (BNA), 520 (Oct. 12, 1988) (CFC producers announce their replacement plans for CFCs); *id.* at 158 (March 9, 1988) (a joint statement by several U.K. companies on CFC phaseout and replacements); *id.* at 109 (Feb. 10, 1988) (announcement on a substitute for CFC-113); *id.* at 667 (Dec. 14, 1988) (announcement on the removal of coolants from automotive air conditioning systems); Koenig, *Carbide Says New Chemicals Can Wean Foam Makers From Chlorofluorocarbons*, Wall St. J., Aug. 5, 1988, at 26, col. 5 (announcement on developing chemicals which will allow manufacturers to produce foam without using CFCs).

174. Montreal Protocol, *supra* note 21, art. 8.

175. Vienna Convention, *supra* note 20, art. 11, para. 1.

176. *Id.*, art. 11, para. 2.

resolved by negotiation or mediation, it accepts compulsory arbitration as a means of dispute settlement.[177] Alternatively, the dispute may be submitted to the International Court of Justice (ICJ).[178] If neither arbitration nor ICJ jurisdiction is agreed to by the parties involved, a Conciliation Commission is to be created upon the request of one of the parties to the dispute, whose "final and recommendatory award" the parties must consider in good faith.[179] The Vienna Convention provisions, which apply to the Montreal Protocol as well by reference,[180] aptly encompass a workable compulsory dispute settlement mechanism. This is a welcome development in the face of a general reluctance to the acceptance of third-party decisionmaking in the international arena.

The second challenge pertains to standing. It is desirable that both states and nationals have standing to redress compliance issues resulting from the 1987 Protocol. This would insure the most effective enforcement of the Protocol because citizen enforcement actions would augment governmental actions to protect the ozone layer.

The third and most formidable challenge relates to the selection of remedies. The problems with the use of equitable or injunctive powers of an international commission are obvious in the international arena which is characterized by a horizontal structure. However, the parties can certainly draw upon the prior experience of regional and bilateral commissions on air and water issues[181] and, despite a poor record thus far of the development of international environmental law on liability and compensation,[182] they should address an attempt to resolve the issue of providing credible remedies.

G. *Research*

The Protocol requires the parties to cooperate in promoting research, development, and exchange of information pertaining to "the containment, recovery, recycling, or destruction of controlled substances."[183] It also calls upon the parties to promote public awareness of the environmental effects of ozone-depletion issues.[184] An interna-

177. *Id.*, art. 11, para. 3(a).

178. *Id.*, art. 11, para. 3(b).

179. *Id.*, art. 11, paras. 4-5.

180. *See id.*, art. 11, para. 6; *see also* Montreal Protocol, *supra* note 21, art. 14.

181. *See, e.g.*, Weiss, *supra* note 123, at 171-76; Parnall & Utton, *The Senegal Valley Authority: A Unique Experiment in International River Basin Planning*, 51 IND. L.J. 235 (1976).

182. *See, e.g.*, Nanda & Bailey, *Export of Hazardous Waste and Hazardous Technologies: Challenge for International Environmental Law*, 17 DEN. J. INT'L L. & POL'Y 157 (1988).

183. Montreal Protocol, *supra* note 21, art. 9. para. 1.

184. *Id.*, art. 9, para. 2.

tional research fund must be established to facilitate the fulfillment of parties' obligations under the Protocol, possibly by requiring contributions of a percentage of a party's production and consumption levels. The fund would be used to help develop alternatives to controlled substances and the use of better technology for improving containment, recovery, recycling, and destruction of controlled substances. Such a fund would ensure that some steps were being taken to develop new ways to solve the ozone depletion problem. This is likely to prompt states to act or to at least fund research activities.

H. *Appraisal*

Although there is merit to the criticism that the Protocol has failed to more decisively act in accord with scientific evidence, and consequently that little meaningful change will occur in an effort to stop the depletion of stratospheric ozone by the year 2000,[185] the following analysis will show that the Protocol is an important and promising, albeit small step, toward an international commitment to rectify the ozone depletion problem. Although much more needs to be done now,[186] perhaps no "tougher" agreement could have been reached in September 1987.

The Protocol is a landmark in the ongoing development of international environmental law, primarily because the world community showed a rare consensus in accepting the imposition of strict controls on states for activities potentially harmful but having caused no proven specific damage or harm. As Mostafa Tolba said after the adoption of the Protocol, "[n]ever before in the history of science and law has the international community agreed to take such radical steps to avert a problem they anticipate, before that problem has begun to take its toll."[187] Another major strength of the Protocol lies in its formula on its entry into force,[188] and its provisions on review and amendment.[189]

First, the Protocol recognizes the special interest of the European

185. *See, e.g.*, 10 Int'l Env't Rep. (BNA), 581, 582 (Nov. 11, 1987) (statement of F. Sherwood Rowland, who first linked chlorine with depletion of stratospheric ozone).

186. *See, e.g.*, THE ENVIRONMENTAL POLICY INSTITUTE/INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH, SAVING OUR SKINS: TECHNICAL POTENTIAL AND POLICIES FOR THE ELIMINATION OF OZONE-DEPLETING CHEMICAL COMPOUNDS (Sept. 1988) (the report recommends a phase out of CFCs and other chlorine compounds not covered under the Protocol by the end of the century).

187. Cited in Menyasz, *International Agreement to Protect the Ozone Layer Hailed as Precedent for Global Environmental Solutions*, 10 Int'l Env't Rep. (BNA), 531 (Oct. 14, 1987).

188. *See* Montreal Protocol, *supra* note 21, art. 16.

189. *See id.* at arts. 2(a), 6.

Economic Community to be treated as a distinct entity, capable of becoming a party in its own right. Prolonged negotiations led to a resolution of the initial objection by the United States that it would set a "dangerous international precedent."[190]

Second, it ensures that states becoming parties are not likely to face unfair competition from non-parties to the Protocol by requiring ratification or accession by at least eleven states and international economic entities (such as the EEC), representing two-thirds of global consumption of CFCs and halons.

Third, it appropriately mandates compliance by the parties, without reservations, with the Protocol's control measures , as well as with its restrictions on trade with non-parties.[191]

Fourth, the Protocol allows special treatment for developing countries,[192] and those with planned economies.[193] The objective, obviously, is to seek wider participation, but there is an inherent danger that these exceptions, in addition to those on controlling trade with non-parties,[194] are dysfunctional.

Finally, the Protocol provisions on review and amendment[195] allow the parties to revise their control measure by adding new compounds or changing emissions reductions in response to further research and scientific evidence.[196]

Ironically, as the following analysis shows, the Protocol is also seriously flawed because its control measures are inadequate to accomplish the Protocol's objective of halting ozone depletion. It is noteworthy that current scientific evidence has now convinced two persons highly influential in the formulation of the Protocol control measures, UNEP's Executive Director Mostafa Tolba[197] and EPA Administrator Lee Thomas,[198] that a strengthening of the Protocol is essential to achieve a decrease in the stratospheric chlorine levels. In October 1988, Tolba told a UNEP conference on the protection of the ozone layer that the scientists studying the problem had concluded that at least an 85 percent emissions reduction, instead of the 50 percent reduction called for under the Protocol, is necessary to reduce the

190. *See* Menyasz, *supra* note 187, at 533.

191. *See* Montreal Protocol, *supra* note 21, at arts. 16-18.

192. *See id.* at arts. 2-5, 16-19.

193. *See id.* at art. 2, para. 6.

194. *See id.* at art. 4.

195. *See id.* art. 2(a)(10).

196. *Id.*

197. 11 Int'l Env't Rep. (BNA), 581, 582-83 (Nov. 9. 1988).

198. *Id.* at 555, 556 (Oct. 12, 1988).

levels of atmospheric chlorine to the level of twenty years ago.[199]

There are other problems with the control measures. The Protocol does not control emissions of two other ozone-destroying chemicals, methyl chloroform and carbon tetrachloride, which reportedly account for 13 percent of projected ozone depletion.[200] In the case of halons, the Protocol provides only for a freeze on consumption but not for reduction in production levels.[201] There are no restrictions on products which are produced with or contain CFCs and halons.[202] And finally, the treatment of production rights of the controlled substances as proprietary rights, thus allowing a transfer of these rights,[203] raises questions about the efficacy of the control measures.

In light of the growing scientific evidence on the potential risk of continued ozone depletion,[204] the parties to the Protocol must convene for a review as soon as practical to consider accelerating the rapid elimination of emissions.[205] The Protocol needs to be amended, mandating an immediate 85 percent CFC emission reduction, leading to an eventual total phaseout in 10 years[206] and appropriate restrictions on other ozone-depleting chemicals. Also, a continuing vigilant review of the impact of market forces on the development of substitutes and replacements is essential. A complete, rapid ban on certain uses of these controlled substances may become necessary.

An analysis of the Protocol reveals further limitations and deficiencies in several provisions addressing issues of compliance, trade sanctions and remedies, and developing and planned economy countries.

As a starting point, the Protocol does not define noncompliance, nor does it establish the necessary institutional machinery to determine noncompliance with the control measures. It obligates the Parties at their first meeting to create the needed institutional mechanisms

199. *Id.* at 582.

200. *Id.* at 680 (Dec. 14, 1988) (statement of a World Watch Institute researcher); *Id.* at 677 (statement of a NASA official).

201. Montreal Protocol, *supra* note 21, art. 2, para. 2.

202. *See id.* at art. 4, paras. 3-4.

203. *See id.* at art. 2, para. 5.

204. In addition to notes 50-52 *supra* and accompanying text, see 11 Int'l Env't Rep. (BNA), Current Reports 668 (Dec. 14, 1988) (reports of rising melanoma rates with depletion of stratospheric ozone layer).

205. This is in accordance with Montreal Protocol, *supra* note 21, at art. 2, para. 10 and art. 6.

206. A promising development occurred on March 2, 1989, when the 12-member European Economic Community agreed to ban all production and use of CFCs by the end of the century. Whitney, *12 Europe Nations to Ban Chemicals that Harm Ozone*, N.Y. Times, Mar. 3, 1989, at A1, col. 6. The next day, the United States endorsed the proposal. Shabecoff, *Bush Backs Halt in Use of Pollutants in Ozone*, N.Y. Times, Mar. 4, 1989, at 9, col. 1.

and procedures for the determination of noncompliance.[207]

UNEP, with its prominent role in negotiations and the signing of the Protocol, has to be the leading candidate as the lead agency where the secretariat is located.[208] However, delegates at Montreal feared that UNEP's limited resources might be strained by assuming the role as the lead oversight agency.[209] Another concern on UNEP's possible selection is related to its location in Nairobi.[210] An alternative suggestion is that of WMO, which is centrally located in Geneva, and has a long history of active participation in ozone research and monitoring projects since 1976.[211] Both UNEP and WMO have indicated their willingness to be the lead agency, hosting the Protocol secretariat.[212]

Both of these agencies are well-suited to perform the functions of the overseeing agency, so the selection of either one is appropriate. An effective arrangement would be to ask UNEP to be the lead agency, with WMO sharing a major responsibility for further research, which has to be extensive, and monitoring as well.

Once the lead agency is selected, effective procedures must be established for verifying emissions reduction. First, however, accurate statistical data are essential on the production and export-import of the controlled substances for 1986. The Protocol obligates the Parties to provide such data to the secretariat.[213] Developed countries can, of course, satisfy this requirement, but for many developing countries it may be difficult to meet their obligations, unless the lead agency and developed countries assist with technical aid.[214] Furthermore, objective fact finding in the international system remains a formidable hurdle. It will require ingenuity on the part of the lead agency and the Parties to agree upon verifiable fact-finding procedures, the lack of which continues to plague negotiators on arms control issues as well as those addressing violations of international human rights.

A most important role for the lead agency will be to facilitate research, development, and exchange of information on appropriate technologies for production of substitutes and replacements for CFCs and halons, and for their containment, recovery, recycling, and de-

207. Montreal Protocol, *supra* note 21, arts. 8, 11, para. 3(d).

208. *See id.*, art. 12 (functions of the secretariat).

209. *See* Menyasz, *supra* note 187, at 534.

210. *Id.* at 534-35.

211. *Id.* at 535; 11 Int'l Env't Rep. (BNA), 581 (Nov. 9, 1988).

212. *See id.*

213. Montreal Protocol, *supra* note 21, art. 7.

214. *See id.*, arts. 9-10.

struction.[215] As the Protocol obligates the Parties to promote such activities either directly or "through competent international bodies,"[216] the role of the lead agency is bound to be crucial in assisting many developing countries which lack the needed financial resources as well as technology to find suitable substitutes at acceptable economic cost.

Trade sanctions constitute a powerful and persuasive tool to encourage wider participation in the Protocol. The Protocol appropriately provides an adequate machinery for mandatory settlement of parties' disputes under the Convention.[217] Policymakers will have to address two important issues concerning the Protocol language.[218] One, the Protocol does not ban or restrict the import from non-parties of products containing controlled substances or those "produced with, but not containing controlled substances."[219] This loophole needs to be plugged soon. Second, sanctions on international trade are rarely taken and are almost never effective. The experience of the General Agreement on Tariffs and Trade on dispute settlement[220] and of sanctions against Rhodesia and South Africa[221] illustrate this point.

The inadequacy of sanctions under international law brings into sharper focus the lack of enforceable remedies in the Protocol. Voluntary compliance based on a recognition of the congruence of national interest with global interests in halting emissions of ozone-depleting chemicals, of course, offers the most effective method available to meet the Protocol objectives. However, to face the issue of noncompliance by an intransigent state, it is essential that the Parties must address questions related to state responsibility, liability, and compensation.[222] Needless to say, no existing mechanism can enforce decisions of an

215. *See id.*, art. 9.

216. *Id.*

217. *See* text and notes 175-189, *supra*.

218. *See id.*, art. 4.

219. *See id.*, art. 4, paras. 3-4, art. 10.

220. *See generally* Hudec, *GATT Dispute Settlement After the Tokyo Round: An Unfinished Business*, 13 CORNELL INT'L L.J. 145 (1980).

221. *See generally* C. BROWN-JOHN, MULTILATERAL SANCTIONS IN INTERNATIONAL LAW — A COMPARATIVE ANALYSIS (1975); L. KAPUNGO, THE UNITED NATIONS AND ECONOMIC SANCTIONS AGAINST RHODESIA (1973); Doxey, *The Rhodesian Sanctions Experiment*, 25 Y.B. WORLD AFF. 142 (1971); Doxey, *International Sanctions: A Framework for Analysis with Special Reference to the U.N. and South Africa*, 26 INT'L ORG. 527 (1972); Report of the U.N. Special Committee on Apartheid, *Policies of Apartheid of the Government of South Africa: Implementation by States of United Nations Resolutions on Apartheid*, U.N. Doc. A/9168 (1973) (*id.* at 5, "the United Nations Action on *apartheid* has remained far from effective.") U.N. sanctions continue to have little effect on the South African economy.

222. *See* Nanda & Bailey, *supra* note 182; 11 Int'l Env't Rep. (BNA), 468 (Sept. 1988) (report on principles adopted by the International Law Commission at its 1988 meeting in Geneva on international watercourses.)

international body against a major power or even not so major a state. This statement is especially valid on the use of force in the international arena, as witnessed in conflicts in Vietnam, Afghanistan, Central America, and between Iran and Iraq. However, the general proposition holds, since there are no effective remedies that a world body can impose. The International Court of Justice's decision in *Nicaragua v. U.S.*[223] provides an apt illustration of such lack of enforcement.

The Protocol's concern with the needs of developing countries[224] and centrally planned economies[225] has some validity. After all, developing countries are not big consumers of controlled substances,[226] and it may be considered necessary for development purposes that some allowance be made for some increases of such substances in their production and consumption. Given the percentage of global population covered under this exception, the Parties must ensure in their review after five years that it has not resulted in significantly increasing global consumption of CFCs and halons.[227] It may, however, be difficult to revise the exception in favor of centrally planned economies because of the short-term time frame and a limited increase in per capita consumption levels.[228]

In sum, drastic modifications of the Protocol are essential, which will test the will and vision of the Parties at their first review meeting as well as succeeding meetings.

VII. Developments Since the Protocol

A. *Developments in the United States*

The signing of the Montreal Protocol was a signal to industry to move swiftly in their efforts at recycling CFCs, chemically modifying them, or finding suitable replacements to meet the reductions called for in the Protocol.[229] In contrast with their earlier position marked

223. 1986 I.C.J. 14 (Merits) provides an apt illustration.

224. Montreal Protocol, *supra* note 21, art. 5.

225. *Id.*, art. 2, para. 6.

226. *See id.*, art. 5, para. 9; Reportedly, the developing countries consume an average .2 kilograms per capita (kg/capita) annually, which under the Protocol will be permitted to rise to .3 kg/capita annually. Menyasz, *supra* note 187, at 534.

227. *But see* Menyasz, *supra* note 187, at 534 (UNEP executive director's statement to the effect that developing countries are financially and technically incapable of taking advantage of the favorable treatment they are provided under the Protocol).

228. *See* Montreal Protocol, *supra* note 21, art. 2, para. 6.

229. *See, e.g.*, Maugh II & Stammer, *Loss of Ozone Calls for Speedy Action, Experts Say*, L.A. Times, March 21, 1988, at 16, cols. 2-3.

by combative responses to their critics,[230] DuPont, the world's largest manufacturer of CFCs, announced in March 1988 its plans to phase out all production of the chemicals.[231] Although no target date was set for ending production of CFCs, a company official said that "reducing output by at least 95 percent by the beginning of the next century was a 'reasonable goal.' "[232] Reportedly, industry does not consider compliance with the Protocol to require major efforts.[233]

The United States was among the first states to ratify the Montreal Protocol.[234] The Protocol took effect on January 1, 1989,[235] when the following conditions had been met: one, that the Vienna Convention enter into force, which occurred on September 22, 1988;[236] and two, that at least 11 parties to the Protocol representing at least two-thirds of 1986 estimated global consumption of the covered substances ratify the Protocol, which took place in December 1988.[237]

In the meantime, while the U.S. Environmental Protection Agency and the U.S. Congress have been actively pursuing the issue, states and cities have also begun to take the initiative.[238] EPA is the lead agency responsible for the implementation of the Protocol,[239] and members of Congress have demonstrated their concern by holding hearings and proposing legislation on the subject.[240]

1. *EPA Rulemaking in Response to the 1987 Protocol*

As early as in 1978, the EPA and the Food and Drug Administration had banned the use of CFCs as aerosol propellants in most aerosol

230. *See, e.g.*, Glaberson, *Behind DuPont's Shift on Loss of Ozone Layer*, N.Y. Times, Mar. 26, 1988, at 17, col. 3.

231. *See* Shabecoff, *DuPont to Stop Making Chemicals that Peril Ozone*, N.Y. Times, Mar. 25, 1988, at A1, col. 2.

232. *Id.* at col. 2. For a representative earlier position of the industry, see STRATOSPHERIC OZONE DEPLETION & CFCs, *supra* note 44, at 273 (statement of Chemical Manufacturers Association), and 360, 384, 394, 402, 412, 499, 584, 657, 660 (statements of several industry representatives).

233. *See* Shabecoff, *Industry Acts to Curb Peril in Ozone Loss*, N.Y. Times, Mar. 21, 1988, at A11, col. 1.

234. 88 DEP'T ST. BULL., June 1988, at 68.

235. 12 Int'l Env't Rep. (BNA), 3 (Jan. 11, 1989).

236. 88 DEP'T ST. BULL., Aug. 1988, at 92.

237. 12 Int'l Env't Rep. (BNA), 3 (Jan. 11, 1989).

238. *See, e.g.*, N.Y. Times, Aug. 26, 1988, at 11, col. 1 (a foam producer settles a lawsuit brought by the State of Massachusetts to stop CFC emissions in violation of state regulations); 11 Int'l Env't Rep. (BNA), 333 (June 8, 1988) (action by Minnesota); *id.* at 457 (Aug. 10, 1988) (action by the City of Los Angeles).

239. EPA's rule-making statutory authority is pursuant to the 1977 Clean Air Act Amendments, § 157(b), 42 U.S.C. § 7457(b) (1977). For the Act, *see id.*, §§ 7450-7459 (1977).

240. *See infra* notes 273-291 and accompanying text.

products such as spray cans.[241] After the ban went into effect, CFC manufacturers found new applications for their product. This resulted in an unsuccessful attempt to reduce total CFC production. With the signing of the Montreal Protocol, however, a new opportunity has arisen to reduce production and consumption of ozone depleting chemicals such as CFCs and halons. As part of its obligation to implement the 1987 Montreal Protocol, the United States is required to obtain data on U.S. 1986 production, exports, and imports of all of the controlled substances[242] that are covered in the Protocol. On December 14, 1987, the EPA therefore required all U.S. firms which produced, exported, or imported the controlled substances to report by January 14, 1988, the amount of CFCs that a company produced, exported, or imported, in 1986.[243]

Furthermore, the EPA proposed regulations under § 157(b) of the 1977 Clean Air Act[244] to implement and correspond to the terms of the 1987 Montreal Protocol.[245] Terms of Section 157(b) authorize the EPA Administrator to promulgate regulations to control any substance, process, practice, or activity which may reasonably be anticipated to affect the stratosphere, "if such effect may reasonably be anticipated to endanger public health or welfare." Essentially, the Ad-

241. *See* 43 Fed. Reg. 11301, 11318 (1978). The EPA also calculated the costs and benefits of the proposed regulation. The costs would total approximately $27 billion for the period 1989-2075, while the benefits were estimated to range from $29 billion to $340 trillion for the same time period. *See* 52 Fed. Reg. 47513 (1987).

242. CFCs and halons as set out in Annex A of the Protocol. *See supra* note 145.

243. 52 Fed. Reg. 47486, 47488 (1987) (to be codified at 40 C.F.R. pt. 82).

244. 42 U.S.C. §§ 7457(b) (1977).

245. 52 Fed. Reg. 47498 (1987). According to EPA's estimates, compliance with the Protocol by most states would reduce ozone depletion to 1.3 percent by the year 2075. *See* Table 2 below.

TABLE 2
OZONE DEPLETION LEVELS FOR
ALTERNATIVE REDUCTION OPTIONS
[Percent depletion of total column ozone]

Case	2000	2025	2050	2075
1. No Controls.	0.9	3.9	12.4	39.9
2. CFC freeze..	0.8	2.3	4.3	6.2
3. CFC 20% ..	0.8	1.9	3.4	5.0
4. CFC 50% ..	0.8	1.5	2.3	3.2
5. CFC 80% ..	0.8	1.2	1.6	2.2
6. CFC 50%/ Halon freeze	0.8	1.3	1.6	1.3
7. CFC 50%/ Halon freeze/ U.S. 80% ...	0.8	1.2	1.4	1.2
8. U.S. only/ CFC 50% ..	0.8	3.1	8.5	20.4

52 Fed. Reg. 47499 (1987). The EPA had also evaluated the risks of ozone depletion in EPA, ASSESSING THE RISKS OF TRACE GASES THAT CAN MODIFY THE STRATOSPHERE (Dec. 1987).

ministrator is not required to prove that a substance, process, practice, or activity does in fact deplete stratospheric ozone levels before such regulation may be enacted.[246]

The EPA believes that the 1987 Montreal Protocol's requirements are an appropriate response at this time to the potential ozone depletion problem.[247] Thus, EPA proposed a control strategy that would implement the 1987 Montreal Protocol. First, the EPA decided that requiring the U.S. to do more than the Protocol requires could be counterproductive since other nations might have less incentive to join the Protocol. The lack of international support which occurred when the U.S. banned CFCs in aerosols shows that unilateral U.S. action does not necessarily lead other nations to reduce their emissions.[248]

The EPA's logic is correct. However, while steps must be taken to ensure that other nations join the United States in an attempt to find an effective solution to the problem, it is essential that the United States take an aggressive leadership role to fight for future reductions at subsequent meetings that are required to be held under the 1987 Protocol. Also, regardless of what other nations do, the U.S. should require that CFC- or halon-containing products be labelled as such and that the consumer be informed of the potential harms resulting from a product's use. This will allow informed consumers the choice to purchase products that do not contain CFCs and halons if an alternative exists.[249]

The EPA considered control strategies such as regulatory fees, auctioned rights, engineering controls, and chemical bans.[250] It proposed to allocate "rights equal to the quantity of allowable production and consumption to producers and importers of controlled substances in 1986, [stating that] [s]ince producers and importers are small in number (probably no more than 15 to 20), it would be far less burdensome to allocate rights to them instead of users."[251] Firms could buy

246. Pursuant to § 113b of the Clean Air Act, 42 U.S.C. 7413 (1977), the EPA can also impose penalties for noncompliance of up to $25,000 per day per violation. Each kilogram of controlled substance produced or imported beyond a firm's allocated rights would be considered to be a separate violation. EPA also has the authority to seek injunctive relief to halt further production or imports if a firm has already reached its allocated rights limit for the year. 52 Fed. Reg. 47505 (1987). The EPA may bring criminal penalties against persons who knowingly violate the allocated rights limitation system. *Id.* These penalties will help to enforce the 1987 Protocol's limitations upon U.S. producers and importers of the controlled substances as set out in the Protocol.

247. 52 Fed. Reg. 47499 (1987).

248. *Id.*

249. EPA is still studying the question. *See infra* note 268.

250. *See* 52 Fed. Reg. 47499-500 (1987).

251. *Id.* at 47500.

and sell rights to respond to changes or market conditions.

This proposal will erect formidable barriers to entry since the present CFC producers and importers would have the allocated rights to produce or import CFCs. Production rights held by a firm would authorize them to produce up to the level of production rights held by the firm.[252]

Limiting production and granting specific production rights to a handful of companies has the potential for windfall profits that could be reaped by such companies, especially if the supply of controlled substances is decreased and the demand for the controlled substances stays the same or increases. The EPA did address the question "as to whether possible profits from continued production of the restricted chemicals might have the undesired effect of delaying the introduction of less profitable chemical substitutes."[253]

As a result of the controlled marketplace, a windfall profits tax must be levied against the producers and importers of the controlled substances in order to recover the increased earnings that result because of the restricted supply.[254] The funds could also be used to administer the controlled substances program, and to enforce any violation of the program. It also seems desirable to set up a research fund with the tax money to support further research of new chemicals that could be used as safe substitutes for the controlled substances. This would insure U.S. implementation of Article 9 of the 1987 Montreal Protocol which calls for the promotion of research.

Subsequently, in May 1988, following a public hearing on its proposed rules, the EPA issued a supplementary proposal setting forth company-specific apportionments of production and consumption rights.[255] Then on August 12, 1988, the EPA promulgated its final rule on protection of stratospheric ozone.[256] The rule is to take effect upon the day the Montreal Protocol enters into force.[257]

The Agency interpreted § 157 (b) as not requiring the Agency to prevent potential harm,[258] but authorizing it to assess the risks of

252. *Id.* at 47500-501.

253. *Id.* at 47507.

254. EPA has subsequently considered adding a regulatory fee to supplement the allocated quota system. 53 Fed. Reg. 30603, 30605-36010 (1988).

255. 53 Fed. Reg. 18800 (1988).

256. 53 Fed. Reg. 30566 (1988). *See also* EPA, REGULATORY IMPACT ANALYSIS: PROTECTION OF STRATOSPHERIC OZONE (Aug. 1988).

257. 53 Fed. Reg. 30566 (1988).

258. 53 Fed. Reg. at 30568. EPA said: "Reasonably anticipated harm connotes a likely harm or a harm whose likelihood and magnitude together are large enough to make preventive measures reasonable." *Id.*

stratospheric ozone depletion and to regulate as the assessment warrants.[259] Responding to the critics' complaint that the Montreal Protocol and consequently EPA's proposed rule "did not go far enough fast enough in requiring reductions in ozone-depleting substances,"[260] for what was needed was a virtual phase-out of CFCs and halons,[261] the Agency made one significant concession. While proclaiming the final rule, the EPA gave an advanced notice of proposed rulemaking, which discussed replacing allocated quotas with an auction system or supplementing the final rule with a regulatory fee and/or engineering controls or bans on specific uses of CFCs and halons.[262]

Estimating that windfall profit could range from $1.8 to $7.2 billion through the turn of the century,[263] the existence of which could result in delaying the introduction of chemical substitutes,[264] the EPA left the question of regulatory fees,[265] auctions,[266] a command-and-control system,[267] and labelling[268] for future action, following public comments on the proposal.

The EPA's review of the impact of these alternative strategies to implement the Montreal Protocol is thorough and its approach reasonable and sound. It has had ample experience with "controlled trading" in its effort to meet the ambient air quality standard under the Clean Air Act.[269] The EPA, by virtue of its experience with emissions trading,[270] its research on economic and legal issues involved in ozone regulatory schemes,[271] and solicited public comments it receives

259. *Id. See also id.* at 30568-30573.

260. *Id.* at 30574.

261. *Id.*

262. *See id.* at 30604 (1988).

263. *Id.* at 30606.

264. *Id.*

265. *See id.* at 30606-14.

266. *See id.* at 30610-14.

267. *See id.* at 30614-18.

268. *See id.* at 30618-19.

269. As amended in 1977, Clean Air Acts Amendments of 1977, Pub. L. No. 95-95, 91 Stat. 685, amended by Safe Drinking Water Amendments of 1977, Pub. L. No. 95-190, § 14, 91 Stat. 1393, 1399-1405, recodified at 42 U.S.C. §§ 7401-7642 (earlier codification at 42 U.S.C. §§ 1857-1858a).

270. *See generally* Calvo y Gonzales, *Markets in Air: Problems and Prospects of Controlled Trading*, 5 HARV. ENVTL. L. REV. 377, 396-430 (1981); Landau, *Economic Dream or Environmental Nightmare? The Legality of the "Bubble Concept" in Air and Water Pollution Control*, 8 B.C. ENVTL. AFF. L. REV. 741 (1980); Mandelkar & Sherry, *Emission Quota Strategies as an Air Pollution Control Technique*, 5 ECOLOGY L.Q.. 401 (1976); Comment, *Regulating with a Carrot: Experimenting with Incentives for Clean Air*, 31 BUFFALO L. REV. 193, 201-31 (1982); Note, *The EPA's Bubble Concept After Alabama Power*, 32 STAN. L. REV. 943 (1980).

271. *See* 53 Fed. Reg. at 30606 (EPA initiated two studies of its own to examine the issues of quotas and regulatory fees). For citations to these studies by S. Decaino and Sobotkin & Co., Inc., see *id.* at 30619.

from concerned parties,[272] is well suited to devise a workable, equitable, and efficient scheme.

2. *Action in Congress*

The Committee on Science, Space, and Technology of the U.S. House of Representatives held a hearing in October 1987 to review the results of the 1987 Antarctic Ozone expedition.[273] Those testifying included representatives from the U.S. Department of State,[274] EPA,[275] NASA,[276] NOAA,[277] and National Science Foundation.[278] The focus was on the 'very clear chemical signature' in the evolution of the Antarctic ozone hole,[279] and on the adoption and ratification of the Montreal Protocol.[280] Assistant Secretary of State John Negroponte surmised that with the signing of the Montreal Protocol, "we have entered into a new era of global environmental management," for changes in the ozone layer affect the entire world.[281]

In July 1988, U.S. Senators Robert Stafford and Timothy Wirth each introduced a broad piece of legislation in the United States Senate,[282] addressing primarily the questions of stratospheric ozone depletion and the greenhouse effect respectively. Senator Tim Wirth's bill called for a reassessment of the control measures within a year of the enactment of the bill.[283] It also required the U.S. Secretary of State to

> actively encourage the adoption of additional control measures requiring the virtual elimination of emissions of all substances identified in the Montreal Protocol within five to seven years from the date of enactment of this title and appropriate control measures for other ozone-depleting chemicals not identified in the Montreal Protocol.[284]

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272. *See id.* at 30607-19.

273. *See Review of the Results of the Antarctic Ozone Expedition, Hearings Before the Committee on Science, Space, and Technology of the House of Representatives*, Oct. 29, 1987., 100th Cong., lst Sess. 77 (1988).

274. *Id.* at 12-18 (testimony and statement of John D. Negroponte, Assistant Secretary for Oceans and International Environmental and Scientific Affairs, U.S. Department of State).

275. *Id.* at 19-26 (testimony and statement of A. James Barnes, Deputy Administrator, EPA).

276. *Id.* at 340-60 (testimony and statement of Robert T. Watson, Chief, Upper Atmosphere Research Program, NASA).

277. *Id.* at 361-72 (testimony and statement of Adrian Tuck, Aeronomy Lab, NOAA).

278. *Id.* at 373-82 (testimony and statements of NSF representatives).

279. *See, e.g., id.* at 340-60, 361, 362-63 (testimony of Adrian Tuck, a strong advocate of dynamism and 'meteorological signatures').

280. *See* generally *id.* at 3-4, 12-26.

281. *Id.* at 12.

282. *See* Stafford Bill and Wirth Bill, *supra* note 12.

283. Worth Bill, *supra* note 12, at § 1503(a).

284. *Id.* at § 1503(b).

With slight modifications, Senator Wirth reintroduced the bill on February 2, 1989.[285]

Senator Stafford's bill, entitled "The Global Environmental Protection Act of 1988,"[286] proposed stringent controls, providing for a virtual elimination of halogenated CFC use and sale by 1999.[287] The Act required the President of the United States to request the United Nations to establish a new temporary agency, to be headed by the UNEP director, to:

> (1) Coordinate international efforts to minimize and mitigate the effects of unavoidable environmental alterations; and
> (2) provide financial, technical and other assistance to developing nations to facilitate improvements in their domestic standards of living while minimizing or eliminating contributions to global, continental and sub-continental scale environmental damages.[288]

In introducing the bill, Senator Stafford urged the U.S. Senate to take the lead in the ongoing efforts toward protection of the environment.[289] While the bill was not enacted by the 100th Congress, it was reintroduced in the 101st Congress by Senator Patrick Leahy.[290] Another bill of note introduced in the 101st Congress is the Global Environment Research and Policy Act of 1989, which provides a mechanism for planning and coordinating long-term research efforts on global climate change involving more than two federal agencies.[291]

3. *EPA Findings*

In August 1988, the EPA released a report entitled, *Future Concentrations of Stratospheric Chlorine and Bromine*,[292] which relates rates of emissions to stratospheric levels of chlorine and bromine. It also examines the reductions required "to stabilize the atmosphere at

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285. Senate Bill 324, cosponsored by 30 Senators, 135 CONG. REC. S1036 (daily ed., Feb. 2, 1989).

286. Stafford Bill, *supra* note 12, at 10112, 10282.

287. *Id.*, §§ 102(6), 103, 107(f). Section 107(f) provides, "Effective January, 1999, it shall be unlawful for any person to produce or release [substances to be phased-out and regulated, including halogenated CFCs] for any use other than medical purposes."

Section 103(b) states the national goal:

> [T]o eliminate atmospheric emissions of manufactured substances with ozone depleting potential, including chlorofluorcarbons and other halogenated carbons with ozone depleting potential, and to reduce significantly emissions of other gases caused by human activities that are likely to affect adversely the global climate.

288. *Id.* § 302(a).

289. Stafford Bill, *supra* note 12, at 10114.

290. Senate Bill 333, 135 CONG. REC. S1069 (daily ed., Feb. 2, 1989).

291. 135 CONG. REC. E362 (daily ed., Feb. 9, 1989); *id.*, S522 (daily ed., Jan. 25, 1989).

292. EPA, *Future Concentrations of Stratospheric Chlorine and Bromine* (Office of Air and Radiation, Aug. 1988) [hereinafter *Future Chlorine and Bromine Concentrations*].

current levels of chlorine and bromine."[293]

The report states that "chlorine and bromine levels will increase substantially from current levels" even with substantial global participation in the Montreal Protocol.[294] Specifically, chlorine levels are likely to grow by 2075 by a factor of three from current levels, even with 100 percent global participation in the Protocol, assuming methyl chloroform emissions grow, which the Protocol does not regulate.[295] Assuming that methyl chloroform emissions do not grow, chlorine levels would still grow by a factor of 2.2 by 2075, and assuming a total elimination of emissions, "stratospheric chlorine levels will continue to grow for about 6-8 years" because of transport delays to the stratosphere and long life times of these compounds.[296]

The report summary noted:

> Very large increases in Clx and halon abundances would have been expected if the use and emissions of chlorine-containing compounds and halons had been allowed to increase without limit. The provisions of the Montreal Protocol will reduce the amount of the increase significantly, but will not keep the levels of Clx and halons in the stratosphere from increasing. Significant additional reductions in emissions are required to keep the levels from increasing, possibly including a complete phaseout of the fully-halogenated compounds and a freeze on methyl chloroform. The rate of substitution with partially-halogenated chlorine-containing compounds will also influence future chlorine levels.[297]

Subsequently, in September 1988, the EPA Administrator called for a strengthening of the Protocol, "with a near-total phase-out of chlorofluorocarbons as the goal."[298] He stated that, persuaded by the recent scientific data of the need to do more, he had written the UNEP and "his international counterparts, urging them to consider tightening the agreement."[299] He, however, was not sure whether "we ought to phase out [the regulated chemicals] 50 percent in 10 years and 95 percent in 15 years, or it may be that we ought to hit 95 percent in 10 years."[300]

B. *International Developments*

Other notable developments since the signing of the Protocol in-

293. *Id.* at 1.
294. *Id.*
295. *Id.*
296. *Id.*
297. *Id.* at 27.
298. 19 Env't Rep. (BNA) 985 (Sept. 16, 1988).
299. *Id.*
300. *Id.*

clude, in addition to its ratification by 29 states and the European Economic Community by December 31, 1988,[301] further research and action by governments in several countries, including Canada,[302] European countries,[303] and Japan.[304] Among international organizations, UNEP[305] and WMO[306] remain the most active entities in conducting and promoting further research, while the European Community Commission has actively pursued the subject of implementation in Europe.[307] In March 1989, the European Economic Community agreed to a ban on CFCs by the turn of the century.[308] Industry[309] and consumers groups[310] have also participated in working toward the implementation of the Protocol.

VIII. CONCLUSION

The growing concern with stratospheric ozone depletion found concrete expression initially in the 1985 Vienna Convention and two years later in the Montreal Protocol. The Vienna Convention provided a framework initially for international cooperative efforts in research and monitoring as well as information exchange, and later for presenting firm commitments and obligations in the Montreal Protocol. The shocking revelation of the antarctic ozone hole spurred the world community to take anticipatory action to protect the fragile ozone layer.

Would early accords to prevent further damage to the ozone layer have been possible without the ozone hole? An interesting question, but more important inquiry relates to impact on the future development of international environmental law. As a prospective prescriptive instrument, could it provide a model for agreements on such

301. 12 Int'l Env't Rep. (BNA) 3 (Jan. 11, 1989).

302. *See, e.g.*, 11 Int'l Env't Rep. (BNA), 110 (Feb. 10, 1988); *id.* at 310 (July 13, 1988).

303. *Id.* at 156, 158 (Mar. 9, 1988), 440 (Aug. 10, 1988), 601 (Nov. 9, 1988), 643 (Dec. 14, 1988) (United Kingdom); *id.* at 157 (Mar. 9, 1988) (West Germany); *id.* at 211 (April 13, 1988) (the Netherlands and Sweden).

304. *E.g.*, 10 *id.* at 582 (Nov. 11, 1987), 11 *id.* at 157-58 (Mar. 9, 1988), 11 *id.* at 212 (April 13, 1988).

305. *E.g.*, 11 *id.* at 225 (April 13, 1988), 11 *id.* at 581, 581-84 (Nov. 9, 1988), 11 *id.* at 644, 644-45 (Dec. 14, 1988).

306. *E.g.*, 11 *id.* at 581 (Nov. 9, 1988), 11 *id.* at 644, 644-45 (Dec. 14, 1988).

307. *E.g.*, 11 *id.* at 155 (Mar. 9, 1988), 11 *id.* at 314, 314-15 (June 8, 1988), 11 *id.* at 581-82, 584-85 (Nov. 9, 1988).

308. *See supra* note 206.

309. *E.g.*, 11 Int'l Env't Rep. (BNA), 110, 112-13 (Feb. 10, 1988), *id.* at 158 (Mar. 9, 1988), *id.* at 227-28 (April 13, 1988), *id.* at 324 (June 8, 1988), *id.* at 520, 520-521 (Oct. 1988), *id.* at 650 (Dec. 14, 1988).

310. *E.g.*, 10 Int' Env't Rep. (BNA), 492 (Oct. 14, 1987) (Swiss consumers federation seeking boycott of aerosols containing CFCs).

matters as transboundary air pollution, especially the acid rain issue, and global warming? An important feature of the ozone issue, perhaps distinguishing it from others such as acid rain, is that the economic cost of the proscription is not prohibitive. Another attractive feature of the Montreal Protocol, after it becomes operational, is that Parties will not face unfair competition from non-Parties. In the development of international environmental law, the Protocol certainly stands as a milestone.

Next, a speedy reappraisal of the Montreal Protocol's control mechanisms is in order. It is essential that controls are responsive to the latest scientific findings, which call for much greater reductions than were proposed in the 1987 Protocol. Lee Thomas and Mostafa Tolba[311] have already called for a strengthening of the Protocol, in light of findings estimating increases in chlorine levels, even given optimistic assumptions concerning the implementation of the Protocol.[312] Without further reductions in ozone depletants, further depletion in stratospheric ozone levels will occur and plague our planet for many centuries to come. The only way to actually test out our scientific theories is to let nature take its course and see if future reality mirrors today's predictions. We live in an imperfect world with imperfect access to information and imperfect scientific knowledge which makes decision-making imperfect. If humanity has to err, where the future of human health, welfare, and the environment is concerned, it makes sense to err on the side of over-protection instead of acting too little too late. The risks are too high to act half-heartedly toward preventing further ozone destruction in the future.

The need is critical for extensive and intensified research on ozone-depletion questions, especially on finding suitable substitutes for CFCs and halons, on recycling them, and on making the necessary design changes to reduce their emissions in their use as coolants and solvents, and as important ingredients in the production of foam.[313] It is equally important that developing countries receive the appropriate transfer of technologies and technical assistance they sorely need.

Will the international community be able to respond in time? Albert Schweitzer once said that "[M]an has lost the capacity to foresee and to forestall. He will end by destroying the earth."[314] By our actions on this major challenge of our time, the international community can prove him wrong.

311. EPA Administrator and UNEP Executive Director, respectively.

312. 11 Int'l Env't Rep. (BNA), 556 (Oct. 1988).

313. *See generally* discussion at 53 Fed. Reg. 47509-47511 (1987).

314. R. CARSON, SILENT SPRING vii (1962).